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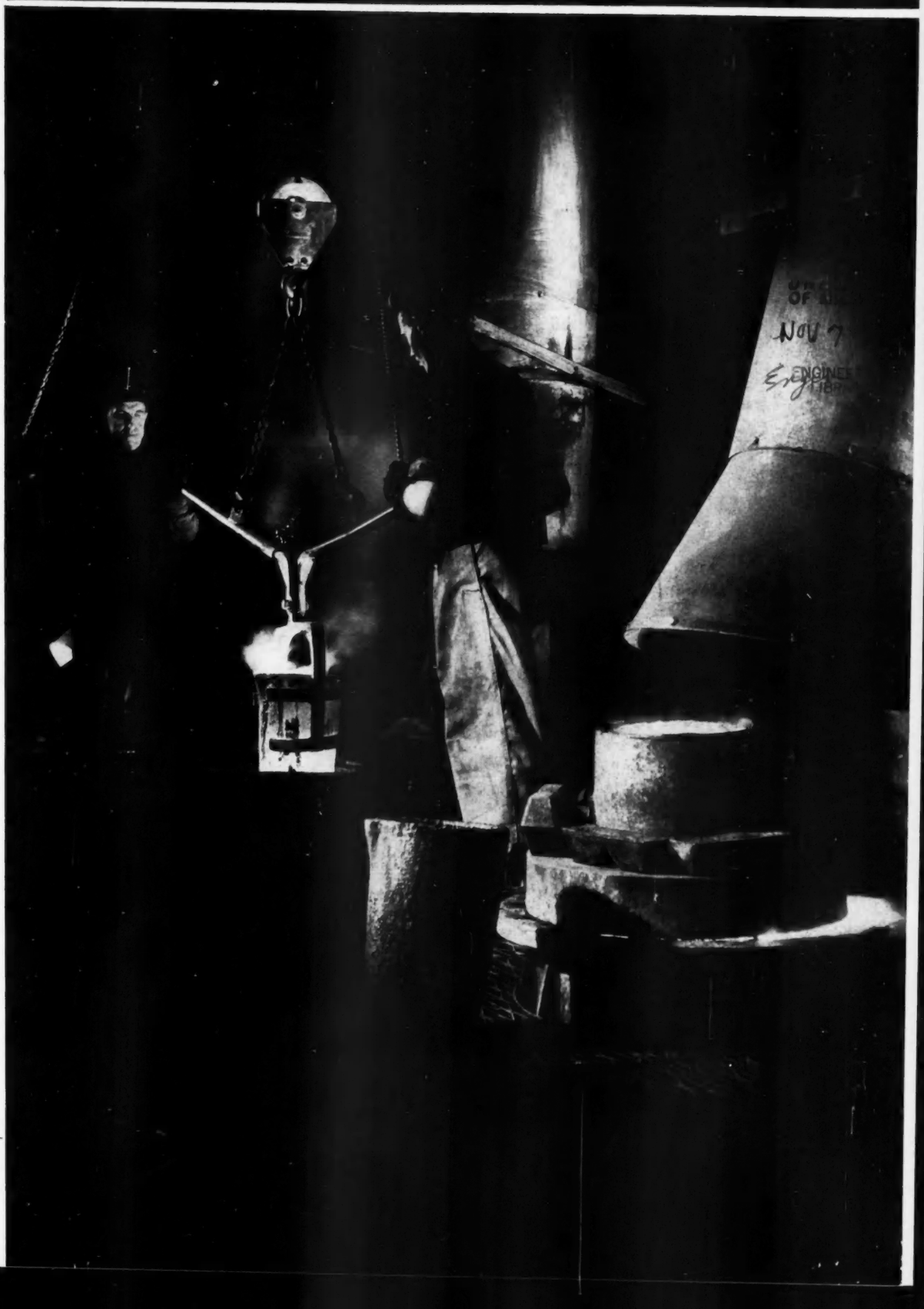

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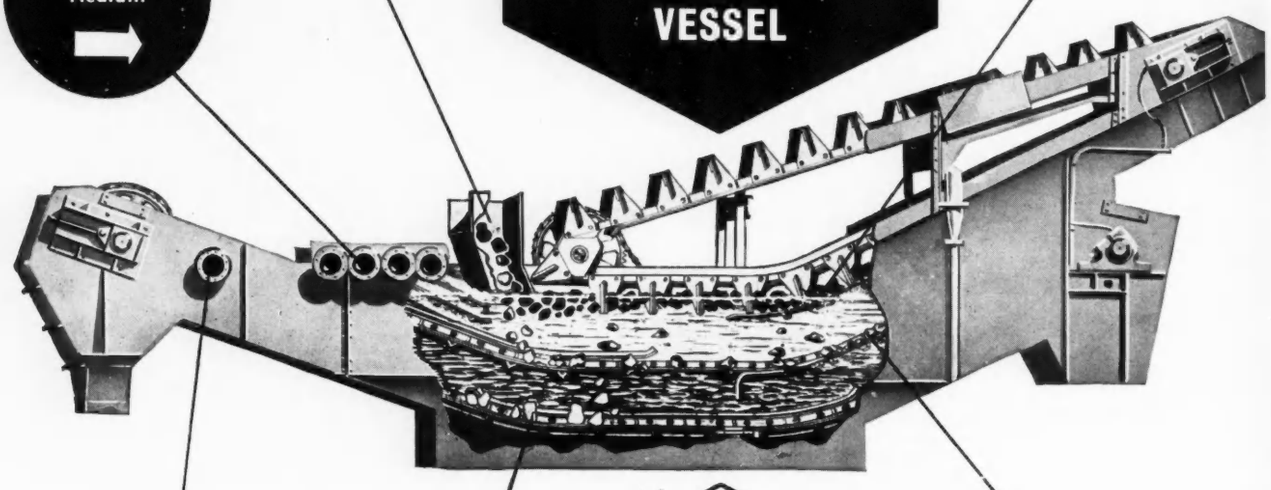

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ENGINEERING

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Healthy Institutions

For a few weeks at this time of the year, the engineering institutions take on a new lease of life. Presidential occasions, annual dinners and the opening of a new session of papers and meetings start the winter with a swing. The autumn of nature is the spring of the mind.

To-day, Friday, the President of the Institution of Mechanical Engineers gives his presidential address, and last night (after we had gone to press) the annual dinner was held. But the evidence of new thinking and new ideas in this, one of our oldest institutions, will already be apparent to members when they read the October issue of the *Chartered Mechanical Engineer*. By tradition, the institution's summer meeting is held at an engineering centre in the United Kingdom, but next year it is planned to break with tradition and hold the meeting in Switzerland, with Zurich as the main centre of activity. The institution have put out a feeler to members before deciding finally. There is little doubt that this proposal will be welcomed. Most engineers visit several engineering works in their own country during the course of the year, and further visits on a summer meeting are not always very rewarding.

A detail of organisation which will affect all members who attend London meetings of the institution is the decision to change the ordinary meetings from Fridays to Wednesdays. Air Marshal Sir Owen Jones, the President, says that representations have been made to the secretary from time to time that Friday is no longer the most convenient day of the week for members generally. The new meeting day will come into operation at the beginning of the 1959-1960 session. It will leave Tuesday clear for the Institution of Civil Engineers' meetings and Thursday for the Institution of Electrical Engineers.

The " Electricals " are quick to keep up with the latest specialisations in their branch of the profession. They organise sections which meet the wants of particular groups of members. Their latest development in this direction is the formation of a Medical Electronics Discussion Group. The first meeting of the group is to be held on 7 November, when the subject will be the measurement of blood flow. Later meetings will discuss neurophysiology, and the physiologists' requirements for d.c. amplifiers. Engineering has come a long way since it was confined to prime movers, machines and the like. These latest developments, in which engineers play an important part, show that engineering is more even than the " directing of the great sources of power in nature for the use and convenience of man."

Chemical engineering is advancing at a fast pace, and the Institution of Chemical Engineers is keeping up with it. They have recently completed a useful piece of work—a study of the distribution of chemical engineers and an estimate of future requirements. It is difficult to understand why other institutions do not set about carrying out inquiries of this kind on behalf of their members.

Founded in 1908, the Institution of Structural Engineers celebrated their jubilee this year. The President, Mr. Gordon S. McDonald, took the opportunity in his address to doubt the value of a " super " engineering institution founded on the amalgamation of existing institutions. " Such a step," he said, " would lead to utter chaos and the foreigner would be even more puzzled than he is to-day as to the meaning of any British professional title. I cannot conceive that any single professional body could completely control so many specialised branches of engineering, particularly from the point of view of providing adequate technical education." He was most anxious, however, that the institution should " collaborate to the utmost possible degree with other technical bodies whose work is complementary to our own."

The three main institutions were represented at two important international conferences earlier this year; the Conference of Engineering Institutions of the British Commonwealth, and the Conference of the Engineering Societies of Western Europe and the United States. Broad issues of great importance to the countries are discussed at these conferences, such as an estimate of the future demand for professionally qualified engineers in the Commonwealth, the education and training of engineers, experience of public relations for institutions, relations with associations of engineering technicians, abstracting services, the problems of emigrating engineers and exchanges of students to gain experience.

Maybe a profession gets the institutions it deserves. If that is so, the engineering profession is very deserving! There may be too many of them; some of them may be in a state of suspended animation; but there is certainly plenty of friendly rivalry, and not a little vitality, as these examples, taken at random, will show. They are well adapted to the use and convenience of engineers.

Cover Picture.—*Three oil-fired furnaces in a non-ferrous foundry. The middle fume chimney has been swung clear to allow the furnacemen to hoist a pot of molten gunmetal ready for pouring.*

* * *

Plain Words

Otto Skorzeny is a civil engineer in Madrid. The BBC, who gave me this information, didn't say what type of civil engineer he is (whether he is a consultant or a contractor, for example), but no matter—I am sure he is doing the kind of solid, impregnable engineering that civil engineers usually do.

Sixteen years ago his life was very different. He was an Austrian captain of engineers in the Waffen S.S., and it was in 1942 that he led a German commando group entrusted by Hitler with the perilous job of " rescuing " Mussolini from imprisonment in an alpine hotel. He landed his men in several gliders on the rocky upper slopes of the Appenines in Central Italy, surmising that the guards would be so surprised (a reasonable assumption, considering the apparent isolation and inaccessibility of the site) that, by quick action, they could be overpowered or otherwise dealt with. Skorzeny tells the story in his book *Skorzeny's Special Missions*, and the BBC are recounting it in a radio programme on Sunday.

Having seen the spot myself, I admire the audacity of that raid. In 1944, while on leave, a friend and I climbed the mountain—without adequate climbing equipment but with a bottle of Chianti—and we saw the scattered pieces of the wrecked gliders. There is a rope railway or lift affair which takes winter sportsmen up to the hotel and the ski runs—or there used to be—but it was out of action when we struggled up the rough track which ran alongside it. It would have been impracticable for Skorzeny to approach the hotel by either of these routes so he chose a route which the guards had probably never considered.

Skorzeny is now a civil engineer. But adventure does not end for everyone with the return of peace. Take Paddy Garrow-Fisher, for instance. He is preparing his new specially built motor coach, the " Indiaman," for its first journey from London to India. He started this service (basic charge £100 per trip) in 1957 with a second-hand AEC coach, and he is now getting enough passengers to make a regular business out of it. The journey takes about two months and gives you a chance to see 15 countries—across Europe, the Middle East and on to India. When I talked to him a few weeks ago he was just taking delivery of the new coach, and he showed me the air-conditioning, the tiny kitchen at the back and other equipment which will make the journey reasonably smooth. But it's no good going by the Indiaman if you are a luxury-liking traveller. I would like a spell of adventure and hardship myself, before I become a 100 per cent Organization Man.

CAPRICORN

Weekly Survey

Counting Cars

If all the Italians were divided up between the cars in their country they would be queueing up 47 to a car. Americans on the other hand could stretch out at their ease with only three to a car. For Britain and France the number would be 13. West Germans work out at 25, Belgians at 17, Swedes at 10, Australians at six and Canadians at only five. These and other statistics are contained in a recent British Road Federation pamphlet.

Another interesting development is the advance of the diesel. In 1935 only 2·1 per cent of all commercial vehicles in Britain were diesel powered. By 1952 the figure was 9·7 per cent. To-day there are 237,570 diesel-engined vehicles representing 18·1 per cent of all commercial vehicles. The rate of increase in the total number of vehicles, including motor-cycles, since the war is fantastic. The 1957 total of nearly 1½ million vehicles is double that of 1948. The 1958 total is twice that of 1927, which in turn is double the 1921 figure. The revenue from motor taxation in 1957 was over £480 million, compared with £79 million in 1938. Expenditure on roads, on the other hand, totalled nearly £120½ million in 1957 compared with £65½ million in 1938. Motor vehicle exports in 1957 were valued at nearly £308 million, compared with nearly £13 million in 1938. In contrast to these bold advances there is one set of figures that shows a sad decline. In 1904 there were 6,783 tramcars in Great Britain. For some reason or other the big year for trams was 1927 when there were 14,413 of them. To-day there are only 1,612. At the present rate of decline Britain will be a tramless nation by 1963.

Lorries in Low Gear

British commercial-vehicle manufacturers have not participated in the rise in demand for private cars which has lifted production this year to record levels. The latest commercial-vehicle statistics issued by the Society of Motor Manufacturers and Traders and covering the first eight months of 1958 show that production reached a peak of 340,824 in 1955 but fell to 298,609 in 1956 and 290,122 in 1957. At 201,516 production in the first eight months of 1958 shows an improvement on the annual rate in the two previous years but is still well below the 1955 peak. The increase compared with 1957 has been mainly in home sales of vehicles of up to 15 cwt. capacity.

Exports which showed a trend similar to that of production up to the end of 1957 have barely been maintained this year amounting to 81,685 in the period January to August compared with 82,073 in the same period of 1957. Nevertheless the SMMT point out that an international comparison of commercial-vehicle exports over the first six months of the year shows that the British industry is still well to the fore in world markets, British exports being only 13,000 less than the combined exports of Western Germany, France and Italy.

The main reason for the failure of production to increase to any marked extent is of course the general stagnation of industrial production. It has also been suggested that some hauliers have been deferring renewal of fleets through fear of renationalisation. The industry also claims that home sales are restricted by the burden of purchase tax and have pointed out that commercial vehicles are the only item of capital equipment which bears this tax.

An examination of the individual monthly returns shows that in the early months of 1958 total production was noticeably higher than in 1957. Since June, however, this year's production has fallen below that of the corresponding period last year and in the absence of any major change in the purchase-tax situation it is difficult to foresee any immediate improvement.

Say the Bells of St. Clements

The clock in the tower of St. Clement Danes was constructed by Thwaites and Reed Limited, 17 Bowling Green Lane, London, E.C.1. It is a large turret clock, having a one second pendulum and a gravity escapement. A Huygens chain method of winding is used in conjunction with an electric motor. The clock controls a carillon that plays the "RAF March Past", "Oranges and Lemons", and "The Old Hundredth". Westminster chimes are fitted.

The unit that controls the striking, chiming, and initiation of the carillon is mounted above the clock and connected to it by a vertical shaft that turns once an hour. From the shaft, three drives are taken—one turning one revolution in 24 hours, one turning in 12 hours, and one turning once per hour. The last drives a disc fitted with four pegs. These operate a switching system that starts the motor driving the drum carrying the contacts for the Westminster chimes. A further set of contacts on the drum operate in conjunction with a stepped snail to produce the current impulses for the relays operating the striking-solenoid circuits. The snail is used to set a rack, which is set in motion on every hour. A single tooth pinion engages with the rack and operates a switch once per revolution. The snail, which is divided up into 12 positions and revolves once in 12 hours, sets the length of travel of the rack so that the number of rack teeth engaging successively with the pinion is equal to the number of hours to be struck. The system is so designed that every hour, that is every revolution of the chiming control, there is an automatic alignment of the striking and chiming systems, in case these should be out of step, due perhaps to the clock being stopped and reset. When the hands are reset, the snail is adjusted automatically. The shaft turning once every 24 hours serves to mute the clock during certain hours.

Universal Pocket

No one will be surprised to read that the World Bank had a record year in the twelve months ended 30 June 1958. It has been apparent that the prestige of the bank has never been as high both among international creditors and debtors as it has for the last year or so. This high repute has been gradually built up since the bank was established after the war.

During the year 1957-58 the World Bank made 34 loans amounting to $711 million equivalent. It raised in funds through the sale of its bonds and notes to other investors $650 million. The annual report says that the growing number of economic development projects ready and eligible for financing by the bank indicates that " the year may have signalled the start of a new and higher level of operations."

Apart from its lending activities the World Bank helped in negotiating a number of international deals including the compensation paid by the United Arab Republic for the nationalisation of the Suez Canal. It also collaborated in discussions between India and Pakistan for sharing the waters of the Indus basin, a matter which still remains unsolved. Jointly with the Italian Government it undertook the study of a nuclear power station for Southern Italy and when the bids for the station were opened to international competition, it organised an international recruiting panel of experts to analyse the tenders. Loans were made for projects in

18 countries and nearly half the year's lending went to improve communications, particularly railway systems and road construction.

Technical assistance during the year included the maintenance of resident representatives in certain South American republics and sending a general survey mission to Thailand. Seven new countries joined the bank in the year under review—Ghana, Eire, Malaya, Morocco, Saudi Arabia, Sudan and Tunisia—bringing its membership up to 67 and its subscribed capital to $9,405 million.

Gold

The United States Secretary of the Treasury gave his Government's official view last week to the plea from Australia and South Africa that the price of gold should be increased. The decision was expected but it comes at a time when its impact on the economies of these two Dominions may be important. This is particularly true of South Africa which is now beginning to feel the consequences of the world recession. An increase in the price of gold would have been a useful stimulant to the South African gold-mining industry. It is now thrown back on raising its profitability by cutting its costs (a way out of the problem of dealing with the ceiling price which has met with some success so far). Both in Australia and South Africa the lack of a boost for an important mining industry cannot but adversely affect British exports.

The meeting of the International Monetary Fund at New Delhi was much more interested in raising the quotas deposited by member countries with the Fund and this country supported the Canadian resolution for an increase of 50 per cent. Mr. Heathcoat Amory, the Chancellor of the Exchequer, emphasised the time factor when speaking at New Delhi last week. He said that the object should be to have a Fund working with its increased resources by next September. The increase proposed in the quotas is considered essential by the United Kingdom Government, and by the Commonwealth in general, to provide a second line of reserves if sterling is to be made convertible. It may therefore be taken that the time schedule for the increase in quotas is the first fixing point for a further degree of convertibility of the pound. Another one, though this has not been said in so many words, may be the proposed relaxation of imports of consumer goods from hard currency areas which is likely to take place, if there is no financial crisis for sterling before then, sometime next spring. Complete convertibility would probably be easier to bring into operation at that time of the year when the seasonal trend is favourable to the pound.

One problem has to be kept under constant consideration between now and then. This is the trend of the United Kingdom balance of payments. British exports have showed signs of easing off this autumn while the recovery in the United States is beginning to help the price of certain world commodities. If these two trends develop strongly the outlook for the pound would be bound to deteriorate. This deterioration might not last long enough to kill off the plan for further freeing sterling but it would upset the timetable.

Spending on Research

Determining the level of research expenditure is an old and intractable problem. Discussion of it is not made any easier by the too common confusion between pure and applied research, and between research of all kinds and development. Nor, from the human viewpoint, is it safe to rely too far on figures for expenditure as a measure of effort, or for "output" of scientists and engineers as a measure of potential effort available.

Almost the only estimates of expenditure in the United Kingdom were given to the British Association in 1956 by Mr. Ernest Rudd of DSIR, and show a total of £325 million, plus or minus £80 million, spent in 1955 on research and development. This is a fractionally higher proportion of the gross national product than is spent in the United States, though, reckoning in terms of internal purchasing power that £1 may be worth $5 for this purpose, it is less than one-third of the total United States expenditure, and less *per capita*. Similarly, on bare figures, the leaders in the "annual output" of qualified engineers and applied scientists are the USSR (in 1953, 280 per million of population); comparable figures for the United States and the United Kingdom in 1953 were 136 and 57. Such comparisons, in a country dependent on applied brains for survival, let alone progress, are disturbing and rightly so, but the philosophy that demands simply more of everything is unhelpful in this case without the supplementary question—"at the expense of what?". This is not a question of production as for television sets, but of the supply of human beings, of whom, failing a radical change of habits, there is a large but strictly finite production.

An entirely imaginary problem can be created by the fallacy that a man is inevitably fixed in the superficial pattern imposed by his vocational training. Progress and even survival depend on adaptability as much as ability. This must inevitably lead to an interchange of men between industries, between trades and between professions. The engineer must be flexible enough to do this, if only for his own security. Increasingly, engineers will need wider knowledge and understanding, and the remainder will need to be able to talk the language of science and engineering with understanding. "Production" of engineers is dangerous cant. The training of more men, primarily as men, but with an understanding of engineering and scientific method, is essential.

Contents of the Crucible

In the long run what is good for the steel industry is good for the economy as a whole and the engineering industry in particular. About a sixth of finished steel deliveries is directly exported. In the first half of this year the value of total steel exports was about one-tenth down on 1957. Home consumption has also fallen and in August was about 5 per cent lower than a year ago. Stocks, on the other hand, have risen to over 4½ million tons, equal to about four months consumption. All told, crude-steel production was 10 per cent below a year earlier in the second quarter and 16 per cent below in July and August. Imports of steel have further fallen.

Nevertheless, as an article in the *Treasury Bulletin for Industry* points out, the setback in the British steel industry is by no means unique. Compared with a year earlier the fall in production in the United States in April/May was 40 per cent, in Canada 11 per cent, West Germany 6 per cent, and Benelux 7 per cent. The figure for Britain was 10 per cent. The only exception to this general decline was France where, thanks to the big investment programme and the boom in the motor-car industry, production was actually up by 9 per cent.

Looking to the future it is clear that economic expansion of the free world must mean increasing demand for steel. In the United Kingdom, it is probably true to say that expansion should be limited only by the need to safeguard our balance of payments position and maintain stability of price. This expansion will be based on higher investment in plant and machinery accompanied by rising productivity and increased exports. If past trends continue these will be more and more in the form of steel-based products such as machinery and vehicles which already account for half our exports. With American industrial output now at the upturn, and the possibility of increased economic growth in the free world following on the discussions at Montreal and New Delhi, the prospects for expansion are much brighter.

Letters to the Editor

SPEAK FOR BRITAIN

SIR, In your issue of 26 September, Capricorn expressed his embarrassment, in Plain Words, at the "Speak for Britain" advertising campaign. May I say that I share Capricorn's embarrassment but that I do recognise this as a personal matter and one of degree at that. In so far as the campaign corrects a national inferiority complex it is a good thing. In so far as it adds to national complacency it is a bad thing. The difficulty is assessing the balance between good and bad.

This difficulty is associated with another one. Who, what or where is Britain? How does one translate it to a foreigner? The use of the word as a synonym for The United Kingdom of Great Britain and Northern Ireland may be a great convenience but it does seem to be illogical and one cannot help wishing for logic as well as convenience in one's national title.

In the recent conference at Geneva on the Peaceful Uses of Atomic Energy, Britain was referred to extensively, although all the papers and delegates associated with it had officially come from the United Kingdom. The British sections of the two exhibitions at Geneva tended to draw attention to the anomaly. Thus:

Scientific (Palais des Nations)	Industrial (Palais des Expositions)
United Kingdom	Great Britain
Royaume Uni	Grande Bretagne
Grossbritannien	Grossbritannien
Reino Unido	Gran Bretagna
Соединенное Королевство	Великобритания

It is understandable that the British engineering world should have rejected "The United Kingdom" for its practical business, but at the same time is it right to use "Great Britain" and "Britain" as interchangeable alternatives?

Yours faithfully,
A. C. HUTCHINSON.

Old Mill House,
Haynes, Bedfordshire.
9 October, 1958.

EDUCATIONAL EXPEDIENT

SIR, I was shocked to read your Open Letter on the proposal of the Minister of Education to encourage children in secondary modern schools to stay on after the age of 15, as many are already doing. (ENGRG., 10 Oct; '58, p. 459.)

Granted that selection at 11 plus, or at any age, should not debar late developers from acquiring both the training and the positions to which their talents entitle them, it is difficult to see how this objective is to be achieved by denying them the opportunity to continue learning while they are still children. A suitable arrangement of our school system, making it easier for the child to change from one stream to another at a later age, would be better than forcing the child into industry, which, except in a few large companies, will take no interest in his or her further education. And the suggestion that those who find learning difficult should have less of it is surely not compatible with the ideals of a civilised society.

No doubt Russia is adapting her policy to certain hard economic facts; just as those facts have prevented us so far from raising the school leaving age, reducing the size of classes to a reasonable figure or providing the standard of technical education which we so badly need. And no doubt this change in Russian policy is another example of the well-known Communist maxim of "one step backward in order to make two steps forward." But to raise this expedient policy, for which there is no foundation in

Continued on next page

Continuing Letters to the Editor

education theory, to the level of a principle is quite unwarranted.

Yours faithfully,

AUSTEN ALBU.

House of Commons,
London, S.W.1.
11 October, 1958.

TECHNICAL COLLEGES

SIR, To me, and I hope to many others in the field of education, the comparison of the selected colleges has been most instructive, and I think you have excelled in introducing an extremely well balanced article ("Talk of the Town's Technical College," ENGRG., 3 Oct., '58, p. 430.)

I would, however, like to take you up on the views expressed in the last paragraph. I cannot agree that any of the non-technical subjects should be shed to other colleges. I consider that Arts and science subjects and students should be housed under the same roof, so that not only should science students be encouraged to broaden their studies, but that each type of student should have a humanising influence on the other.

Finally, on the question of the high proportion of overseas students in certain courses in this college, there is every justification for this as it is official colonial policy to encourage the flow of student from the Commonwealth, so long as equivalent local facilities are not available. Only in this way can such students train for posts in science and technology, and so help to close the gap between the Western Powers and the under-developed areas. If, in future years, the proportion of students from overseas becomes so large that some English students fail to gain admission to our own technical colleges, then obviously appropriate action must be taken, but at present I see no signs of this happening.

Yours sincerely,

H. V. HILLMAN,
Principal.

Norwood Technical College,
Knight's Hill, London, S.E.27.
8 October, 1958.

TESTING GAS TURBINES

SIR, In your description of the Rolls-Royce plant at Derby for the flight testing of gas turbines on the ground (page 476 of your issue of 10 October), you state that the Jalousy butterfly valve shown in Fig. 4 was supplied by DMM (Machinery) Limited.

May we point out that this and other special valves for the plant were designed, constructed and supplied by Zimmermann und Jansen G.m.b.H. of Dueren, Germany, for whom we act as the English representatives.

Your faithfully,

R. F. NORRIS,
General Manager.

DMM (Machinery) Limited,
66 Victoria Street, London, S.W.1.
10 October, 1958.

SHAW'S ALPHABET

SIR, On page 330 of your issue of 12 September, you endorse (in Capricorn's column) Bernard Shaw's claim that a 40 letter alphabet "could eventually save as much as £3,000,000 a day," on the ground that "a given passage in the English language would take up considerably less space [and] involve correspondingly less work. . . ."

When G.B.S. was himself making these extravagant claims—tons of printers' ink, hundreds of miles of paper, and uncountable man-hours saved a day, many of us who laughed at (or with ?) him could not expose the fallacy. Now, in the light of Parkinson's Law—a light which never, alas, illumined his own brilliant mind, clear and penetrating though it was—the balloon is pricked and ignominiously deflated.

For, just as "work expands so as to fill the time available for its completion," copy expands so as to fill the column-space made available by press-capacity and paper supply. With the proposed alphabet, your contributors, other than mere correspondents, would have to work so much harder, each to complete his allotted stint.

And what of the promised saving of three million pounds sterling a day ? Does your contributor appreciate that this simply means putting a million or more people out of work, or driving them to less congenial occupations than writing, printing and publishing?

Perhaps the greatest tragedy of the Shavian alphabet is the implication that others could do for Shaw, posthumously, with some of the money he accumulated, what he himself was unable to accomplish in his lifetime—if indeed the alphabet is not the greatest leg-pull of all that he perpetrated. Now you yourself, Sir, fall into the same pit by "imploring" your readers to take up the burden. We, your readers, look to you for a lead. Set one of your own draughtsmen the task of designing a 40 letter alphabet—the work of but two or three weeks—and then adopt it for your Plain Words column leaving four plain column-inches at the bottom.

Incidentally, if rendered into "Basic English," this letter would be 57 per cent shorter, a greater saving than could be obtained by transposing to a phonetic alphabet.

Yours faithfully,

E. H. BATEMAN.

Sandyridge, Upper Bourne,
Farnham, Surrey.
7 October, 1958.

REPRODUCING RADIOGRAPHS

SIR, Following upon the article on piping in ENGINEERING of 15 August, I was interested to read Mr. R. O. Couchman's letter on page 428 of your issue of 3 October. While agreeing that the reproductions in the article are positive bromide prints and have, unfortunately, lost a lot of detail in reproduction I think they illustrate their respective points, i.e., longitudinal root piping and a weld free from this defect. Incidentally, the "herring-bone" pattern referred to by Mr. Couchman is frequently encountered where low hydrogen type electrodes are incorrectly used.

There is always a loss of detail on reproduction and to make an intermediate positive and final negative print would have resulted in even greater loss. The radiographs were made by the single wall technique on an 8 in inside diameter pipe with an obvious loss of density towards the edges of the film. It should also be noted that these radiographs were prepared to a high standard of contrast and sensitivity, and were not originally prepared with reproduction in mind.

Nevertheless, there is certainly room for improvement in the reproduction of X-ray negatives and I shall be interested to study the new method which Mr. Couchman promises to describe.

Yours faithfully,

J. HILL,
Radiologist.

Welding Research Department,
Quasi-Arc Limited,
Bilston, Staffs.
9 October, 1958.

REGENERATORS

SIR, My attention has been drawn to the article "Heat and the Engineer" by Professor O. A. Saunders, on page 419 of your issue of 26 September.

In a section of this article, Professor Saunders implies that the idea of a regenerative heat exchanger, employing either fixed or rotating matrices, is comparatively new and that little practical use has been made of this type of heat exchanger.

In fact, this company has been engaged in the development and manufacture of rotary regenerative heat exchangers for over 30 years, and these have found widespread application throughout the world for the recovery of heat from the waste gases of water-tube boiler installations up to the largest sizes.

Yours faithfully,

J. E. SAYERS,
Chief Engineer.

James Howden and Company Limited,
195 Scotland Street,
Glasgow, C.5.
8 October, 1958.

PAYING WAGES MONTHLY

SIR, When, in 1912, I was an apprentice with an engineering firm in Berlin, wages were paid to the nearest full mark, while the pfennigs were debited or credited to the worker's wage account. Thus, a man to whom 81·50 marks were due, would receive 82 marks with 50 pfennigs debited to his account; whereas another, to whom 63·49 marks were due, would receive 63 marks, with 49 pfennigs carried forward on his account. Only in the final pay-off was the full balance paid out. The method worked smoothly.

If such a method were adopted in this country, preferably with all amounts calculated in shillings, a man to whom £10 1*s* 6*d* were due would be paid 202*s*, while his forthcoming wages would be debited with 6*d*; whereas another, to whom £12 3*s* 5*d* were due, would receive 243*s*, with a credit of 5*d* to his wage account. This method would, obviously, simplify wage accountancy with an appreciable saving in time and cost. It would not make any difference to the wage earner.

The making out of wage cheques, if adopted, would likewise be simplified by the reduction of the amount to a single figure. Legal aspects of the matter and safeguards against robbery have already been discussed.

Yours faithfully,

A. LASSALLY

57 Onslow Road,
Richmond, Surrey.
11 October, 1958.

RETORT TO RED ELEPHANT

SIR, In his letter in your issue of 3 October (page 428), Mr. Norman Morton questions the accuracy of a figure quoted by London Transport in commenting on statements made in his Blackpool paper.

The figures given are correct, and any misunderstanding must be due to the fact that Mr. Morton has, as he said, not read our full reply. In this we stated that "over 250,000 people arrive in the central business area between 7 and 10 a.m." by bus, coach, or trolleybus.

The 9 million to which Mr. Morton refers, relates to passenger *journeys* on our road services in a day in the whole London Transport area and not to the number of individual passengers. One individual can, of course, represent several journeys in a day. The figure of 250,000 we quoted as passengers coming into Central London between 7 and 10 a.m. by road services represents the individual people arriving.

Yours faithfully,

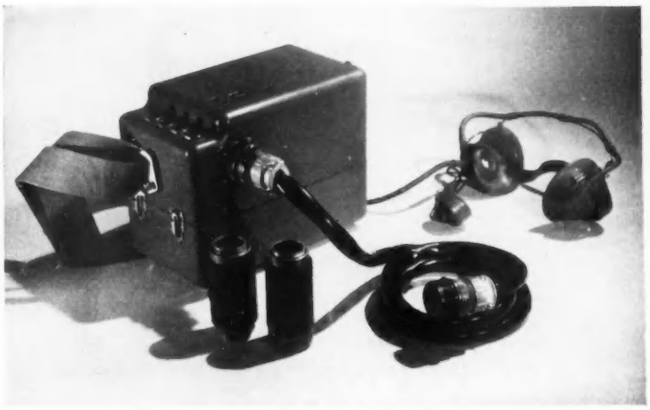
R. M. ROBBINS,
Chief Public Relations Officer.

London Transport Executive,
55 Broadway, London, S.W.1.
9 October, 1958.

Plant and Equipment

PORTABLE TESTER FOR MULTI-CORE CABLES

A portable tester that automatically indicates a faulty conductor in a multiple-core electrical cable (up to 25 ways) has been developed by de Havilland Propellers Limited, Hatfield. Primarily designed as a portable test set for checking aircraft cable installations, the instrument is equally useful in the manufacture and inspection of connector sets, where the small size of the equipment leads to economical use of bench space, and in the inspection of cable runs in ships, mines, communications systems, and similar applications.



This portable set, weighing 19 lb, enables the continuity and insulation of multi-core cables to be tested rapidly.

Either a continuity or an insulation check can be carried out from one end of a cable run, the far end being terminated by a small unit weighing less than ½ lb. A test is initiated by press button and the instrument automatically selects each wire in turn. The identification of the core undergoing test is indicated in a window, which is illuminated by a red light if failure occurs, in which case the selector stops at the faulty core. Successful completion of a test sequence is indicated by the extinguishing of a separate indicator lamp. A reset button prepares the test set for a further test sequence.

A single outlet from the test set can be adapted for use with any cable connector by means of a suitable coupler supplied to the customer's requirements. In the case of a connector having a multi-position keyway, the coding is checked by a clearly marked movable keyway on both the coupler and termination units.

To enable long cable runs to be tested under conditions where the termination unit is more conveniently attached by a second operator, an intercommunication amplifier is incorporated in the instrument, connection being made via the cable under test. Standard service style headsets may be used. When this system is in use the operators receive an audible signal as each test is made, and can distinguish when a cable failure is detected.

In its portable form the cable tester is mounted on a strap which can conveniently be used either as a neck sling or a carrying handle. Power is supplied by a lightweight battery of a type having no free electrolyte, and of sufficient capacity for about 16 hours of normal use. Couplers and termination units can be carried in pouch-belts. For difficult situations, where access to the cable to be tested is limited, a 6 ft extension cable can be used to take the coupler just where it is needed.

A charging unit is being developed which can be incorporated in a transit case for the test set and all accessories. Placing the test set in the case makes the charging connections, and internal regulation ensures that in 4 hours the battery will be fully charged, yet there is no risk of overcharging however long the equipment is left. The state of charge is indicated by a meter. An a.c. power unit is available as a replacement for the battery when the test set is in use on the bench or near a mains supply. The components are shown in the illustration above.

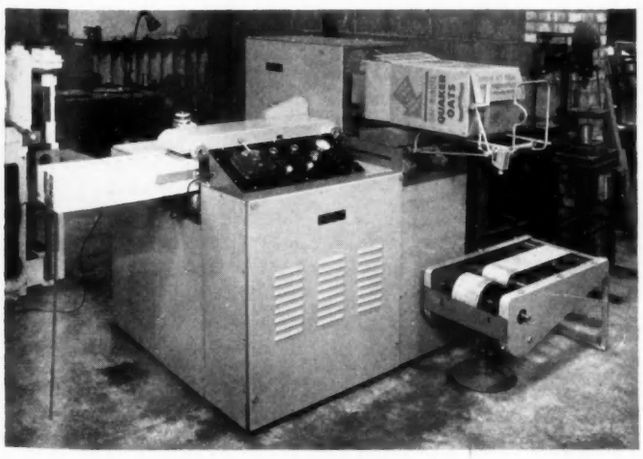
MECHANICAL DUST COLLECTOR FOR URANIUM MILLS

A serious problem in the extraction of uranium from the raw ore is dust—from both the product recovery and air pollution standpoints.

At the Durango plant of the Vanadium Corporation of America promising experiments have been made with a small 25-tube aerostatic unit manufactured by Hagan Chemicals and Controls, Inc., Pittsburgh. This is a mechanical collector of the centrifugal type and has specially formed spiral-vane inlet nozzle to increase the velocity, and thus the efficiency, of dust extraction. The results of these trials, which took place over a period of more than a year, indicated that (i) the unit is definitely an inexpensive one compared with similar high-efficiency collectors, and one that could pay for itself within a week, (ii) its guaranteed efficiencies approached those of an electrostatic unit (the mill requirements were a minimum of 95 per cent collection efficiency), and at one-fifth the cost, (iii) and its self-cleaning feature was outstanding compared with the more expensive wet scrubber, bubbling type and electrostatic models, all of which required to be cleaned regularly.

Situated at 6,500 ft above sea level on a barren mountainside, the Durango Mill operates on a 24-hour basis, extracting uranium and vanadium from carnotite ore mined in western Colorado and the Monument Valley, Arizona. Raw ore is first dry crushed to 10 mesh in giant rod mills, screened in vibration sorters, then fed into nearby multiple-hearth roasters. Here it is treated with 5 per cent salt at 1,600° F. The molten ore is then quenched with 5 per cent soda ash and moved along to an acid leach process as a first step to recovering the uranium and vanadium. The dust problem arises before this stage is reached and is greatest at the conveyor inlets and outlets to the rod mills, and at the vibrating sorters. Although the solid ore contains less than 1 per cent uranium, the ore dust yields a considerably higher percentage of the valuable mineral because of the friable characteristics of carnotite and its recovery is economically important.

In the trials, hoods with ductwork leading to the collector inlet were installed before and after the rod mills, and at the vibrator. Two 10 in blowers powered the overhead dust recovery network. Based on dust samples taken directly from the mill exhaust stack, Hagan engineers calculated that for a flow of 8,000 cu. ft per min and 6 in water pressure drop at an elevation of 6,500 ft and 70° F, the overall efficiency of the collector will be 97·7 per cent, and that for the smaller flow of 6,575 cu. ft per min at 4 in water pressure, the corresponding overall efficiency will be 96·7 per cent. Both efficiencies were based on a normal particle size distribution of 10 per cent less than 10 microns and 30 per cent less than 50 microns. At no time during the trial were signs of wear or tube plugging reported.



Up to 400 packages per hour can be loaded into cartons in this machine.

CARTON PACKING

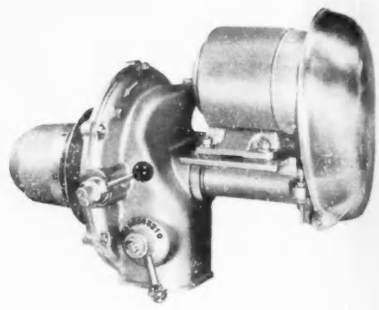
Shown at the recent Chemical and Petroleum Engineering Exhibition by Frederick C. Kane Limited, Park Royal, London, N.W.10, were examples of machines for loading cartons. One type is illustrated herewith. Others included types for cylindrical items such as torch batteries, and there are eight standard basic designs. The operation is that the packages are fed by conveyor to the machine and are then collated in rows and layers. When the magazine is full, the packages are transferred to the carton which is waiting at one side. The filled carton is then automatically discharged on to the take-away conveyor. Up to 400 packages per hour can be handled.

Continuing **Plant and Equipment**

ROTARY OIL BURNER

One of the items that was shown at the recent Industrial Fuel Efficiency Exhibition by White's of Hebburn (Engineers) Limited, Hebburn, County Durham, was their new Spinfire rotary cup oil burner shown in the accompanying illustration. It is suitable for firing boilers with evaporations from 1,000 lb per hour up to 60,000 lb per hour and the maximum oil flow ranges from 90 lb per hour up to 3,300 lb per hour over the nine models available.

The burners have a large range of modulation: the smaller sizes have turn-down ratios up to 4 : 1 and in the larger ones this is increased to 8 : 1. Control may be either fully automatic or by a single lever, manually operated, which controls both fuel and air simultaneously. Fuels up to 6,000 sec Redwood No. 1 may be used. A pressure drop of 4 to 6 in of water across the secondary air register is used in order to give good combustion control over the range of output. The primary air only amounts to about 7 per cent of the total required for combustion.



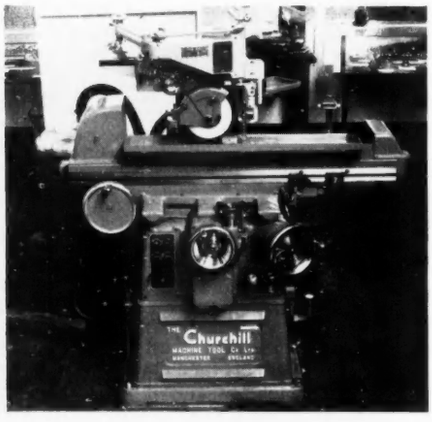
Rotary cup oil burner for fuels up to 6,000 sec Redwood No. 1.

COLLAPSIBLE CONTAINERS FOR CARRYING LIQUIDS

Economies in the costs of transporting certain kinds of liquids are being effected by the use of collapsible containers. A recent development of this method has been the ordering of a " sausage-skin " type of container, having a carrying capacity of 4,000 gallons (approximately 14 tons), for the conveyance of liquids produced in the oil works of the Heavy Organic Chemicals Division of Imperial Chemical Industries Limited, Billingham-on-Tees.

Known as " Portolite," the container's skin is made of rubber, and the container is the first of a new type to be constructed by Marston Excelsior of Wolverhampton, a subsidiary organisation of the Metals Division of ICI. Whereas a tanker normally has to make its journey full in one direction only, returning to its depot empty, the new method enables a lorry to be used for a load in both directions, because the container, when empty, can be rolled up, will lie flat on the floor of the lorry, and takes up little space, thereby providing room for a return load. The combined cost of the lorry and the container is considerably less than that of a tanker, and the container has the further advantage that, where necessary, it can be used on its own to provide a temporary means of storage.

The container is filled by the ordinary methods employed for filling tankers, but it cannot be used for products held in liquid form under pressure. A wide range of uses is envisaged for this type of carrier.



GRINDING MACHINES

Modifications and additions continue to be made to the range of grinding machines manufactured by the Churchill Machine Tool Company Limited, Broadheath, Manchester, and marketed in the United Kingdom by Charles Churchill and Company Limited, Coventry Road, South Yardley, Birmingham 25. The model " BW " 10 in by 36 in plain cylindrical grinder, for example, is now fitted with a wheelhead-mounted power-operated wheel-forming device which is particularly easy to set, and the model " NB " horizontal-spindle surface-grinding machine has built-in Diaform wheel truing and forming equipment.

The latter machine, which has a table working surface of 18 in by 6 in, and will accommodate work up to 9 in maximum height under a new wheel, has been designed for both toolroom and production work. A range of additional equipment is available, including a dust exhauster, wet grinding and swarf separating units, vices, and a small-diameter high-speed grinding wheel. Wheel-crushing equipment for form grinding is also available.

Fitted with the Diaform attachment the machine is particularly suitable for such work as grinding, from the solid, die insertions and similar high-precision complicated components. The Diaform attachment works from a sheet metal template and transfers this form by means of a 10 to 1 reduction pantograph to the grinding wheel. An adjustable template carrier enables the template and the diamond tool to be aligned correctly in relation to the grinding wheel.

Fitted with Diaform wheel forming equipment, the Churchill surface grinder is suitable for toolroom or production work.

PHASE AND CONTINUITY INDICATOR

A pocket-size instrument, which provides visual signals by five neon lamps to indicate the peak voltage sequence in three-phase supply lines and also to identify broken lines, is now being produced by Tiltman Langley Limited, Redhill Aerodrome, Surrey. The whole unit is continuously rated, and three of the lamps are arranged so that if the lines under test are " live " all three lamps light up. In the event of one line being " dead " the lamp associated with that line will light up while the others will remain unlit. Provided that all the lines being tested are sound, phase sequence will be shown by one or other of the two remaining lamps lighting up; phase sequence and line continuity do not use the same lamps.

The instrument is fitted with flying leads terminating in insulated clips or interchangeable test probes, complete with stowage compartment, and measures 3 in by 2 in by 1½ in. The electric parts are " potted " in resin and the weight is 4 oz. Models are available for three phase, 115/200 V, 400 cycles a.c. and for 400 V, 50/60 cycles.

MECHANICAL SWEEPERS

Three sizes of power sweeper are now being made by Matling Limited, 26-32 Caxton Street, London, S.W.1. One is shown in the illustration. The machines are capable of handling most debris encountered in factories, and are double acting in that there are both brushes and vacuum. All larger items are thrown by the brushes (which revolve against the direction of travel) into a hopper, while the dust is sucked into a bag. The hopper is detachable and is mounted on castors. The three models sweep paths of 24 in, 36 in, and 48 in wide. They are driven by a 5 or 8 h.p. petrol engine which powers both road wheels and brushes.

Attachments include a side sweeper; a two-way swivel head, shown in the illustration for sweeping close to walls; and a sulky to permit the operator to ride when sweeping large areas. In all models the brush height is adjustable.

Dust and debris are both collected by the sweeper.

Companies in the News

Doxford's Answers

Recent statements by Burmeister and Wain to the effect that the trend in diesel marine propulsion engines was towards larger single units (Companies in the News, 22 August) were answered by Doxford's new chairman, Dr. J. Ramsey Gebbie, in his annual statement. Referring to criticisms of British marine engine designers for their failure to design and construct engines exceeding 20,000 b.h.p. on a single screw, Dr. Gebbie indicated that Doxford's technical developments had taken a different course. The largest Doxford engine in service has developed up to 9,000 b.h.p., and their latest six-cylinder supercharged engines can be built in powers up to almost 12,000 b.h.p. A new type of engine, tested in a single-cylinder form over the past year or so, is intended to provide powers up to 14,000 b.h.p. " Beyond these powers," said Dr. Gebbie, " we do not at present intend to go because your board and their technical advisers are not yet convinced that the oil engine is necessarily the most suitable prime mover for the propulsion of ships requiring these very large powers on a single screw."

Doxford's expenditure on research and development has been considerable in recent years and a number of major advances have been made. Outstanding among these has been the introduction of a " diaphram system " which enables Doxford's engines to run on heavy oil with the minimum of risk. The application of exhaust turbo-charging, now used on the larger powered ships, has been found very satisfactory and the introduction of a new " timing valve fuel injection system " is said to have met with universal approval. It is in the new design, however, that Doxford place their faith. According to Dr. Gebbie this should be " the beginning of a further period of success for the Doxford engine."

Family Brass

Tradition and deep roots characterise the brass founding industry and family firms abound with third or fourth generations still in control. Even in such a setting, however, the record of the Harlow family is exceptional. Donald F. Harlow, managing director of Robert Harlow and Son Limited, of Stockport, is the great-grand-son of the founder, but Robert Harlow himself came to Stockport as a young man with a family tradition in brass founding of more than a hundred years. The first Harlow to enter the industry, Joseph, learnt clockmaking and brass founding in Birmingham and founded a business there and in Ashbourne in the early 18th Century. His son, Samuel, inherited the two businesses and became a famous clockmaker. Robert, who founded the present firm 125 years ago, was Samuel's grandson.

Robert Harlow carried on the family's clockmaking tradition only a short while (he made the clock of Stockport infirmary) and concentrated on brass founding, making cocks, valves, steam traps, bells, lamps, whistles and other brass products in demand at that time. He began to supply the national market and to export to the Continent and to India. After a short interval of trusteeship when Robert died in 1878, his youngest son, Bernhard, took over and led the firm until 1942, with the help of his son, Frank, in the latter part of this long period. When Frank died only four years after his father's death, his own son, Donald, was not ready but the firm carried on until his arrival in 1951.

Impact of Synthetic Rubber

The recent completion of a £6 million plant of the International Synthetic Rubber Company Limited at Hythe, on Southampton Water, raises the question of rubber supplies in general. What will be the impact of synthetic rubber on the growers of natural rubber in Malaya and Singapore?

Natural and synthetic rubbers are complementary; there are desirable properties in each which are not obtainable in the other. Output from the new Hythe factory, which was completed in 16 months, will satisfy the home demand for synthetic rubber for several years to come, but is merely taking over from vast imports of the material which, up until last July, came from hard currency areas, especially the United States. The saving is $25 million a year, an amount which would fill half the nation's dollar trade gap for the month of July.

Continuing confidence in natural rubber from Malaya and Singapore is adequately expressed by the fact that several of the United Kingdom tyre companies who have subscribed the equity capital of ISR are currently capitalising in new plantations.

Giants Reflect

The operating results for the first half of this year published recently by Imperial Chemical Industries and Vickers both show slightly reduced capacity. The important difference is that Vickers' trading profits before tax are up by 11 per cent, ICI's are down by 19 per cent. Both are paying similar interim dividends—2½ per cent and 2¾ per cent respectively.

ICI's turnover (group sales to external customers) was £3 million less in the first six months of this year than in the corresponding period of 1957 and group income before tax £5·8 million lower at £24·4 million. The announcement explained that trading conditions in the first half of the year were " more difficult than in recent years " and that there had been little change in the total turnover of the products manufactured by the group, " despite the commissioning of new plants." The fall in profits was attributed mainly to the operation of some plants at lower outputs and to increases in wages and salary rates and in fuel and transport charges, without corresponding increases in selling prices. There was also a very large increase in the provisions for depreciation required because more new plants had been brought to the production stage.

Vickers' turnover fell from £94·9 million to £93·4 million in the two half years under review and profits rose from £6·17 million to £6·86 million. The figures of both companies are beginning to reflect the slowing down of industrial activity in the past year in the engineering industry and elsewhere.

Wing Span

The Board of British Overseas Airways Corporation have announced a number of moves to co-ordinate more effectively the services they provide with those of their associated companies in the Commonwealth. A 15-year agreement was signed with WAAC (Nigeria) Limited, whereby Nigerian Airlines will charter BOAC aircraft for the carriage of passengers, mail and freight between Nigeria and the United Kingdom. Initially there will be two Stratocruiser flights a week between Lagos and London. The aircraft will be the same as used by BOAC, and it is expected, therefore, that Stratocruisers will be replaced by Britannias in the summer of next year. It is also planned that Nigerian Airlines will have parity of frequency with BOAC on the route " within a year after the introduction of the Britannia." All traffic revenue will be pooled. As previously announced, the Nigerian Government hold 51 per cent of the equity capital of WAAC (Nigeria), the remainder being divided between the Elder Dempster shipping company (two-thirds) and BOAC whose share amounts to 16⅔ per cent of the total issued capital.

Discussions are currently proceeding to determine the future role of British West Indian Airways and their relationship with BOAC. It has been agreed that a primary function of BWIA is to provide inter-island services in the Caribbean and especially services of importance to the Federation. They will also provide international services important to the economy of the British Caribbean islands linking the islands with neighbouring foreign countries, " provided these services would be self-supporting." The heavy rate of losses incurred by BWIA in the current year, due mainly to a fall in traffic from the USA will be countered by reduced expenditure. Plans for 1959 will be based on a fleet of five Viscounts and three Dakotas which represents a trebling of carrying capacity since 1956 although the number of aircraft has been reduced.

Submarine Crosses Channel by Air

That precedent-setting air transport company, Silver City Airways, has recently added one more unusual operation to its list of accomplishments—the air-ferrying of a submarine across the English Channel! The " submarine " was, in fact, a one-man underwater vehicle which is being used by the French underwater scientist and photographer, M. Dmitri Rebikoff, in undersea cable-survey work off Dungeness that he is undertaking on behalf of British Insulated Callenders Cables Limited and Siemens Edison Swan Limited.

Silver City's normal field of car-ferry operations, now accepted as a commonplace, was itself a trend-setting event just over ten years ago. In that first year they carried 170 vehicles. This year, ended 30 September, they have airlifted 50,006 cars, 4,826 motor-cycles, 1,200 pedal cycles and 153,760 passengers in addition to the midget submarine. This represents an increase of over 60 per cent over their traffic of the previous year. In the same period, the majority of the world's airliners have suffered reverses. Silver City attribute their success to the substantial cuts in air fares that they introduced early in the year.

Airlines Pool Overheads

The advent of jet air transport is proving a mixed blessing. Airlines continuing to operate turbo-prop and piston-engined aircraft are naturally apprehensive that a large part of their clientele will be snatched by their jet-engined rivals if there is no differential in fares; their rivals believe, also naturally, that the new jet transports should carry passengers for the same fares. If these are economic, why not ? The capital outlay has been and will continue to be huge, the profit margin of the world's airlines in the year 1957/58 was a trifling 1 per cent of turnover compared with 3 per cent for the previous year, while the expansion of air traffic is now taking place much more slowly than forecast. Rising costs contribute further to a gloomy outlook.

Against this background the agreement announced last week between the Scandinavian Airlines System and Swissair for exchange of equipment and a joint maintenance organisation makes sense. Both airlines have substantial jet fleets on order; by 1961 these will total 31 aircraft, ten long-range Douglas DC-8's, five medium to long-range Convair 880's, and 16 short-range Caravelles. Of these, seven DC-8's, two Convairs, and 12 Caravelles will be operated by SAS and the remainder by Swissair. Considerable savings are hoped for both by better aircraft utilisation and from more rational operation of the airlines' maintenance facilities.

International competition in this field could at the present time prove ruinous. It is hard to imagine jet aircraft operators agreeing to a jet surcharge after taking the risk of buying the aircraft. It is equally hard to envisage the jetless airlines looking on with complacency as their passengers dwindle—when in fact they may have pursued the wise course financially. Bankruptcy would be an ironic reward for the pursuit of either progress or prudence. There is no hint of a simple answer to these problems.

Special Article

Can Household Grates Give Heat Without Smoke?

DESIGNS FOR SMOKE-REDUCING OPEN FIRES

By W. F. B. Shaw, B.A.(Cantab.), Chief Physicist, Fuel Research Station, Department of Scientific and Industrial Research

The report of the Committee on Air Pollution, published in 1954, called attention to the striking fact that nearly one-half of all the smoke in the air over Great Britain comes from the coal burnt in domestic fires. While it is known that much can be done to reduce the smoke from industrial sources—the problem is one of economics and education rather than of technology—it is clear that air pollution as a whole cannot be seriously tackled unless some way of materially lessening the contribution of domestic chimneys can also be found. That the domestic problem is no mean one is emphasised by the facts that the total amount of coal involved is about 37 million tons, and that some 16 million homes take part in the burning of it.

There are only two ways in which domestic smoke can be reduced. One is to give up using bituminous coal in the home, which would entail the provision of the equivalent of 37 million tons in solid smokeless fuels (natural or manufactured), gas, electricity, or oil, together with the equipment to utilise it. The other is to develop domestic heating appliances which will burn bituminous coal with a lower emission of smoke than the normal grate.

The second of these possible lines of attack has attracted the attention of inventors for the last 150 years. Interest in the subject was considerable during the 19th century, and appears to have reached its peak at about the time of the great Exhibition of the Smoke Abatement Committee in 1882, when some 52 designs of open grate claimed to be "smokeless" were given practical tests. After this there was a sharp decline in interest, though some revival occurred as the result of further trials between 1901 and 1906, organised by the Coal Smoke Abatement Society and generally referred to as the *Lancet* trials since the results were published in that journal. During the inter-war years there was a small but steady output of inventions, while there has been a recrudescence of interest since 1952.

This article sets out to review the work done on the subject of "smokeless" grates, up to 1939. It does not attempt to deal with post-war developments, since it is felt that it is too early yet to form a fair assessment of the technical merit and social impact of the latest work. It is concerned mainly with open types of appliance suitable for heating individual rooms, since these have always formed the main requirement in Great Britain.

NATURE AND PRODUCTION OF SMOKE

Two types of smoke may be distinguished. The first, generally known as "distillation" smoke, is given off in the earlier stages of combustion, when the raw coal is being heated up. It occurs when the distillation of the volatile products has commenced but the temperature has not risen sufficiently for flames to break out. The smoke consists of a suspension of small liquid droplets of a tarry character, and is brown in colour.

The second kind of smoke, known as "carbon" smoke, is emitted at the next stage of combustion when the volatile matter breaks into flame and is the product of incomplete combustion. It occurs if there is insufficient air, or if the mixing of air and volatile matter is inadequate, or if the flame tips are chilled by cold air. Then the heavier constituents of the volatile matter are incompletely burnt, with the formation of lighter gaseous hydrocarbons and particles of carbonaceous material, the smoke being black or dark grey in colour. In practice there are always periods when a fire is emitting both types of smoke simultaneously, distillation smoke predominating just after the initial lighting-up and after each refuelling.

To ensure complete combustion, and so to prevent the formation of either type of smoke, requires that the volatile matter shall be thoroughly mixed with an adequate supply of air, and that the mixture shall be maintained at a temperature of not less than about 800° C for a sufficient time. These conditions do not constitute a major problem when coal is burnt in an industrial furnace, but it is evident that they present very real difficulties in the case of domestic heating grates, especially as regards the maintenance of a sufficiently high temperature.

Although the ways in which it has been attempted to produce smoke-reducing grates are apparently many and varied, it is possible to divide them into four main groups or classes with different basic approaches to the problem:

Class 1—Updraught grates
Class 2—Underfed grates
Class 3—Hopper-fed or coking grates
Class 4—Downdraught grates

UPDRAUGHT GRATES

Class 1—Updraught grates—comprises all grates in which the fuel is burnt on a conventional form of grate bottom, either solid or perforated, but in which some attempt is made to increase the efficiency of combustion. The main lines of approach have been by introducing secondary air in or above the fuel bed, or by shaping the fireback so as to assist combustion,

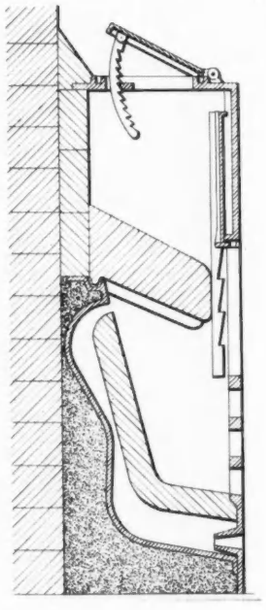


Fig. 1 Everitt and Barnard's "Glow-Fire" up-draught grate.

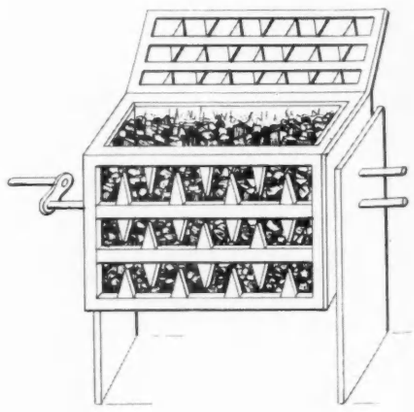


Fig. 2 Jeremiah Spencer's "Fire-Cage" underfed grate.

or by a combination of these. Grates of this class are highly diverse in character. Some appear to be designed on theoretically sound principles but many, examined in the light of modern knowledge, would seem to be largely devoid of any special characteristics likely to result in smoke reduction.

The first recorded designs date from about 1855. That of John Leslie apparently achieved some success in its time as a heating unit, though its smoke-reducing capacity must be suspect. It is described as being wide, but shallow in depth. Air was brought from outside the building through two 1 in pipes and directed into the front of the fire on either side. The fireplace also included a novel provision for ventilation, in the shape of a long slot in the front of the chimney breast, the extent of the opening of which could be controlled by slides or shutters.

In John Lee Stevens's grate, on the other hand, there was a deliberate attempt to introduce preheated secondary air. This was taken through a channel behind the refractory fireback and was directed downwards on to the top of the fuel bed by an inclined metal plate. Everitt and Barnard's " Glow-Fire " (Fig. 1) which was exhibited in 1882, was somewhat similar. Secondary air was preheated in a passage behind the fireback, and then deflected down over the top of the fire by a firebrick baffle. This baffle also formed a partially enclosed space which was expected to assist combustion. The idea was revived again in 1936 by W. C. Goodchild and in the late 1930's by the Fuel Research Station. Goodchild's design also incorporated a canopy, pivoting about its upper edge, which served to divert downwards air entering at the front face of the grate. The front surface of the canopy was concave and its sides were in contact with the side-cheeks of the grate.

E. H. Shorland's " Manchester Grate " won a silver medal in the 1882 exhibition. It was a conventional grate, with firebrick lining, except that there was a channel behind the back brick from which air entered the body of the fire through a narrow slit. In the early 1930's the Fuel Research Station designed a grate along the same general lines. A thin reinforced firebrick partition was spaced about 1½ in in front of the normal fireback, the top of the opening so formed being closed by a projecting cowl. A series of narrow vertical slots at the top of the partition formed passages for warm air from the ashpit to pass into the upper part of the fuel bed.

G. W. Johns (1935) patented a similar arrangement. He formed a chamber between the back and sides of the fireplace and an nner partition lined with refractory material, the air entering the fire through a number of slots in the partition wall. A. E. Page's design of one year later differed only in details, having a more elaborate air-heating chamber behind the fireback.

Two grates in the 1882 Exhibition had fire-backs with deep vertical flutings on their front faces. It was expected that air would rise from the ashpit through the flutings and assist combustion in the upper part of the fuel bed. One weakness of this is that the flutings are likely to become filled with fuel, so that there is no effective air passage. An attempt was made to overcome this in a design due to the Fuel Research Station (*c.* 1931), in which the back brick contained five vertical channels, each 1 in wide, open at the bottom and closed at the top. Each channel was connected to the front face of the brick by a slot about $\frac{3}{16}$ in wide.

In 1926 R. O. P. Theobalds proposed to cover the base of the grate with a series of horizontal tubes, running from the front of the grate and terminating at various points to give a measure of distribution to the air so carried into the body of the fuel.

In addition to the complete grates which have just been described, various devices or " gadgets " have been put forward which are intended to be added to ordinary grates. In 1882 J. G. Gray exhibited a perforated iron grate bottom, to be laid sloping up at an angle towards the back of the fireplace. Again in 1882 J. Wavish was responsible for the " Economiser," a perforated vertical hollow cylinder standing on the middle of the grate bottom with the object of introducing preheated air into the body of the fire. The Fuel Research Station developed a somewhat similar device in the 1930's.

Finally, reference may be made to the CAMA (Combustion Appliance Manufacturers' Association) coal igniter, developed in the late 1930's. It consisted of a gas jet, producing a turbulent flame about 15 in long, which was fixed to the grate so that the flame was directed across the top of the fuel. It was primarily intended to act as an ignition device which would produce less smoke than a conventional gas poker inserted in the body of the fuel, but it could also be used immediately after refuelling if desired.

UNDERFED GRATES

The group of underfed grates is probably the most interesting of the four classes of smoke-reducing fires. The basic idea is that fresh fuel is introduced underneath the burning fuel, so that the volatile matter distilled off has to pass through glowing fuel where it is consumed, at least in part. Various methods of achieving this have been tried, and they may be divided very broadly into two types—those in which a mass of coal burns from the top downwards, and those in which fresh fuel is inserted below the burning fuel, when and as necessary, by some mechanical device or artifice.

The earliest recorded design belongs to the second of these types and dates back to the 18th century. The invention of Benjamin Franklin, it was named by him the " Fire-Cage." The idea was revived in 1818 by Jeremiah Spencer who patented the contrivance shown in Fig. 2. The rectangular-shaped firebox had hinged top and bottom members. When fresh fuel was added this was done through the top opening. The whole box was then rotated through 180° about its horizontal axis, the top becoming the bottom and the burning fuel finishing on top of the fresh charge.

In 1815 John Cutler patented the first of the group of fires which burn from the top downwards, and which in consequence are often referred to as " candle-fires." His grate had front firebars, behind which was a coal box of rectangular section. The box was open at the top and the bottom, a solid plate, could be raised or lowered by means of chains. To start the fire the box was filled with coal with the bottom plate in its lowest position, giving a fuel depth of 8 to 10 in. A fire was then lit on top

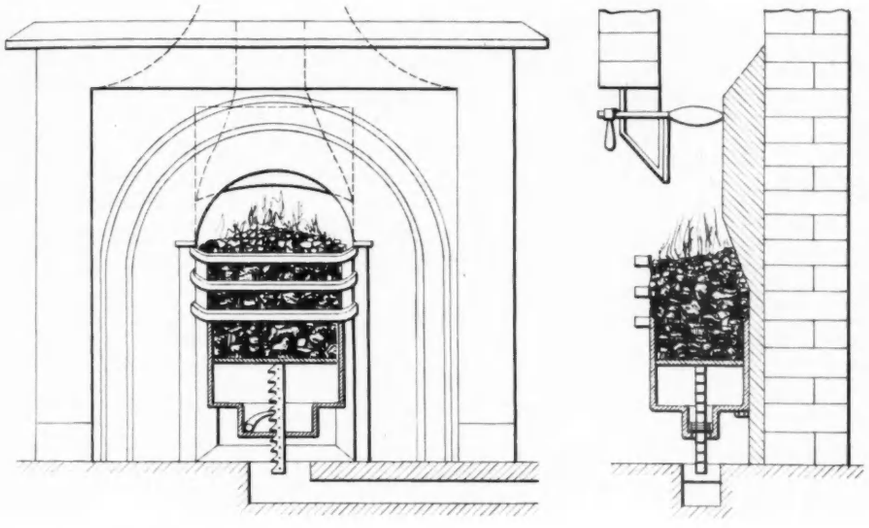


Fig. 3 Class 2—Dr. Neil Arnott's underfed grate.

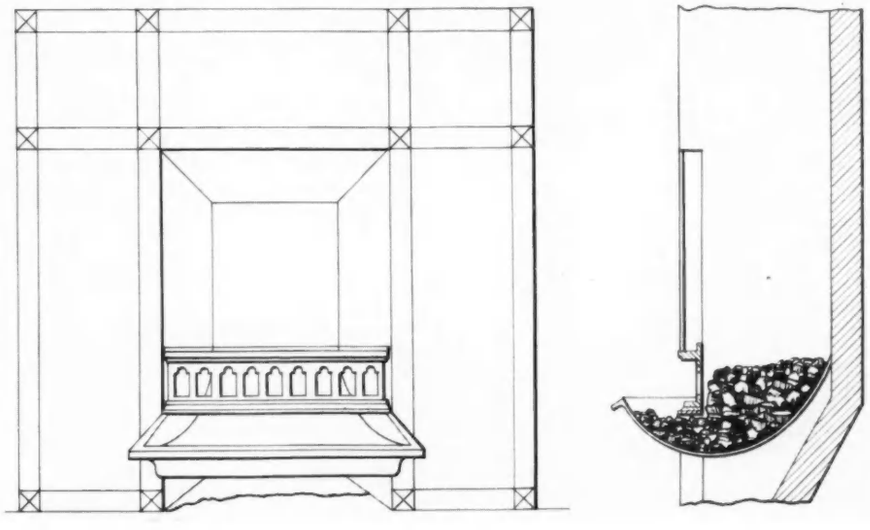


Fig. 4 Class 2—Brown and Green's underfed grate.

Continuing Heat without Smoke

of the coal and, as it burnt downwards, the movable bottom was raised whenever necessary to expose more glowing fuel to view.

Cutler was unfortunate in running into legal difficulties over his patent on what looks, at this interval of time, to have been little more than a technical quibble. It was claimed that his proposals infringed an earlier patent for a kitchen range in which the grate also had a movable bottom, though in this case only to give variation in fuel capacity and with no thought of smoke abatement.

Cutler abandoned his invention in disgust, but the basic idea was revived in 1854 by Dr. Neil Arnott, who produced what is certainly the best known, and probably the most widely used, of all 19th century smoke-reducing grates. Dr. Margaret Fishenden, writing in 1925, stated that specimens were still in existence at that time and that she had seen some in operation.

The main difference between Arnott's grate (Fig. 3) and Cutler's was that the adjustment of the grate bottom was effected by means of a rack and lever. His design also incorporated other features which were uncommon at this time. The fireback was of firebrick and arched over the fire, there was an adjustable flap in the chimney throat by which the area could be controlled, and there was provision for air to be supplied to the hearth from an outside source.

Arnott, who was well known for his interest in heating problems and was also the designer of a closed stove with thermostatic control, did not patent his invention. As a result, numerous variants of the basic Arnott design were produced and marketed within the next few years. Probably the best known was that due to F. Edwards. He lowered the front firebars, used the brick back and sides of the grate to form three sides of the coal box, and dispensed with the space below the box in which dust and ash could accumulate.

Another successful version was produced by J. W. Jeakes. He held the opinion that a movable bottom to the coal box, no matter what system of raising and lowering was employed, would lead to mechanical difficulties. Accordingly he made the sides and bottom of the box fixed and arranged that a plate with firebars above should form the front of the box and be capable of movement up and down by a winding mechanism.

Of other variants on the Arnott design only that due to T. Stevens involved any really radical change. It incorporated a double grate bottom, with one grating arranged to slide over a second, fixed, grating. This arrangement, which was recommended by the inventor as suitable also for use in conventional grates, was claimed to permit some control to be exercised over the supply of air to the fuel.

Turning now to mechanical devices for underfeeding fresh fuel, the first was patented in 1816 by Dowson and Hawkins. It was a box-like shovel which was filled with fuel, inserted at the bottom of the grate, and then the fresh coal pushed out by means of a piston. In the 1882 Exhibition E. H. Shorland submitted a grate whose front firebars were arranged to slide up to allow the insertion of a similar type of feeder shovel.

What is probably the simplest successful form of mechanical underfeeding is that of Brown and Green (Fig. 4) whose grate won the gold medal in 1882. It provided a trough, at the front of the grate and level with the bottom, in which the fresh fuel was placed and then pressed into and below the burning coal by means of a hoe-shaped feeder.

Several designs have been produced in which a movable or insertable grid was provided by which the burning fuel was lifted and supported, so making room for the insertion of fresh coal below it. The grid was then removed and the replenished fire settled down on its permanent grate bottom. Three grates of this type were to be seen in the 1882 Exhibition, that of E. R. Holland securing a bronze medal.

Various other suggestions and patents for underfeed fires are on record, though there is no evidence that they all reached the stage of commercial exploitation. There was, for example, William Young's grate (1856) in which fresh coal was worked into the lower part of the fire by means of a lead screw—an early domestic version of the industrial underfeed stoker. It is stated to have been effective, but unsightly.

HOPPER-FED OR COKING GRATES

The grates of this class may be divided into two groups. Firstly, there are those in which fuel is stored in a hopper or locker in contact with the main fuel bed. The volatile gases pass out through the glowing fuel, leaving a mass of partially carbonised material in the hopper which is drawn out into the firebox as required. The majority of the 19th century designs were of this type.

The first was patented by Atkins and Marriott in 1825. It incorporated a form of hopper, behind the back of the grate, which would hold enough fuel for a day's use. A study of drawings of this grate suggests that there must have been

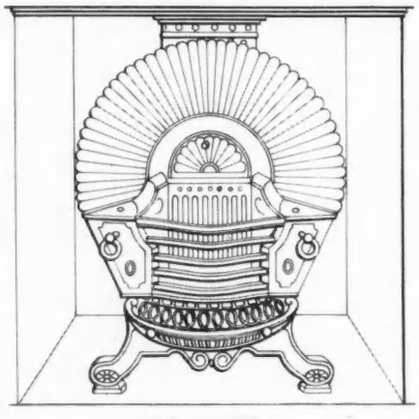


Fig. 5 Class 3—H. E. Hoole's radiating and reflecting hopper grate.

a considerable danger that the whole mass of fuel would take fire in the hopper, though the inventors themselves claimed that their design was inherently much safer in this respect than the Cutler "candle-fire." J. Leighton's grate (1885) was basically similar, but the fuel hopper covered both the back and sides of the fireplace.

The Exhibition of 1882 featured six grates of the hopper type, two of them winning bronze medals. One of these was H. E. Hoole's "Radiating and Reflecting Grate" (Fig. 5). This had two small hoppers or lockers, one at either side, from which the fuel was drawn through openings at the rear lower ends. The grate—more properly a free-standing open fire in present-day terms—was unusual in appearance, being encircled by a fan-shaped surface of cast-iron which was intended to assist the dissemination of heat. The other winning exhibit was that of J. M. Stanley, which had a front hopper and also included provision for convected warm air. A. C. Engert's design had the novel feature that the coal was contained in a coking box which was movable on slides, so that it could be pulled gradually from the back into the body of the fire by means of a rod. The other three grates exhibited followed more or less the conventional pattern, differing mainly in the position of the hopper. The Coalbrookdale Company's "Gassius" grate, with its hopper at the front and a deep outlet to the fire, was noted as particularly effective.

J. Rawe (1854) proposed that fuel should be stored in a receptacle at the side of the fireplace and injected below the burning fuel, when required, by means of a piston-operated force pump. A very similar system was patented in 1926 by R. S. Marsh. In his design the coal was stored in long vertical hoppers on either side of the grate, each having a duct of increasing cross-section leading to the back of the grate. The fuel was forced down the ducts by means of two ramming pistons at the bottom parts of the hoppers. In both grates it was a claimed advantage that small or slack coal could be used.

The second group of devices of this class is distinctive in that they set out to pre-coke a complete charge of coal which is then transferred to the main fuel bed. The first of these, the invention of G. H. Bachhoffner (c. 1855), is probably impracticable, but is worthy of mention because of its novel features. His fireplace had two grate bottoms, one above the other and at an adjustable distance apart. Anthracite or pre-coked fuel was burnt on the upper grate, and bituminous coal on the lower. The volatile matter from the coal distilled off and, it was claimed, was consumed as it passed through the fire in the upper grate. When the bituminous coal became coked it was transferred to the upper grate and the process repeated. A basically similar arrangement was later put forward by W. Warr and J. A. Holland (*c.* 1931). In their system a tray of raw coal was exposed below the fuel bed of an otherwise conventional grate, so that the coal was heated by downward radiation and became partially carbonised. The tray was fitted with two slotted cover-plates, which allowed the volatile matter to pass out but reduced the access of air to the fuel, so preventing any combustion taking place in the tray.

H. E. Warwood (1935) patented an arrangement in which raw coal was placed in trays fitting in two ovens situated at the sides and back of the grate. The ovens were made airtight, and the volatile matter distilled from the coal was released at a pressure of about 1½ in w.g. to burners at either side of the grate. The inventor claimed that slack coal could be used, that the ovens would hold sufficient fuel for a day's supply, and that the resulting coke had a volatile matter content of 7 to 12 per cent.

J. Warr (1930) made a somewhat similar use of the gases distilled from the raw coal which, in this case, was in a closed metal retort running the whole width of the grate back. The gases were piped to a burner below the retort, thus assisting the coking process.

DOWNDRAUGHT GRATES

The term "downdraught" is used here to denote any system in which the products of combustion are withdrawn mainly at a point below the level of the top of the fuel bed. In practice this means extraction through the grate bottom, or through the lower part of the fireback. Although numerous designs have been produced they differ mainly in respect of their ancillary features.

Although Benjamin Franklin's "Pennsylvania Fireplace"—really a free-standing stove in modern nomenclature—was downdraught burning, the first grate to which the principle was applied in this country deliberately for smoke abatement was that of Alexander Williamson (1855). This had a vertical flueway behind the fireback, with apertures leading to it through the fireback. The fire was lit on normal updraught, the back flue being closed until the fire was well established, when it was opened. A year later John Marsh patented a simplified version of this fireplace.

Altogether, some twelve forms of downdraught burning fires were exhibited in 1882, and these won one of the silver and three of the bronze medals. The silver medal went to Ingram's "Kaio-Kapnos" grate (Fig. 6), the name of which is Greek for "burn smoke". The gases were drawn out through a slot in the firebox,

downwards under the floor of the grate and then back again under a horizontal partition plate to the back flue and so up the chimney. This represented an attempt to extract some of the heat from the hot flue gases. M. Feetham's grate was a more complicated device, with what are described as " hollow gill-cheeks " forming a zig-zag course for the flue gases passing up from the closed ashpit. T. E. Parker's " Vencedor " was even more complicated, having, in addition to the main back flueway, a subsidiary flueway to catch smoke rising from the surface of the burning fuel, and a source of preheated air directed at the point of exit of the flue gases. Finally, of the prize-winning exhibits of this type, W. I. Henry's " Calpean " grate had the unique feature that the flue gases, drawn out through slots in the fireback, passed into filter boxes containing iron turnings and thence to the chimney. It was claimed that the turnings would become red hot, so both consuming the smoke and contributing to the radiant output of the fire.

In other designs exhibited the flue gases were variously extracted from the ashpit, either direct or through slots and downward channels in the fireback, or directly through slots and back cases a long way short, of satisfying the conditions which have been defined as necessary for smokeless combustion; the inventors have, in fact, regarded the problem as being much simpler than it really is. To make matters worse there is clear evidence from the tests made in 1882 that, in general, smoke-reducing fires of the types which have been reviewed do not succeed in making use of the heat released by such improvement in combustion as has been effected. Almost without exception it was found that the better a grate was for smoke reduction the poorer its heating capacity, and vice versa. Indeed, in publishing a list of the grates in the order of their heating efficiency, the 1882 Exhibition Jurors had to extend it as far as the sixteenth in order to include the design which was awarded the gold medal.

Updraught fires of Class 1 have always had a particular attraction for the inventor because they both look and handle like ordinary grates, and are therefore likely to appeal to the conservative householder. In the light of modern knowledge, however, it is evident that they can have little effectiveness, and that it is impossible to create conditions which will lead to any marked degree of smoke reduction.

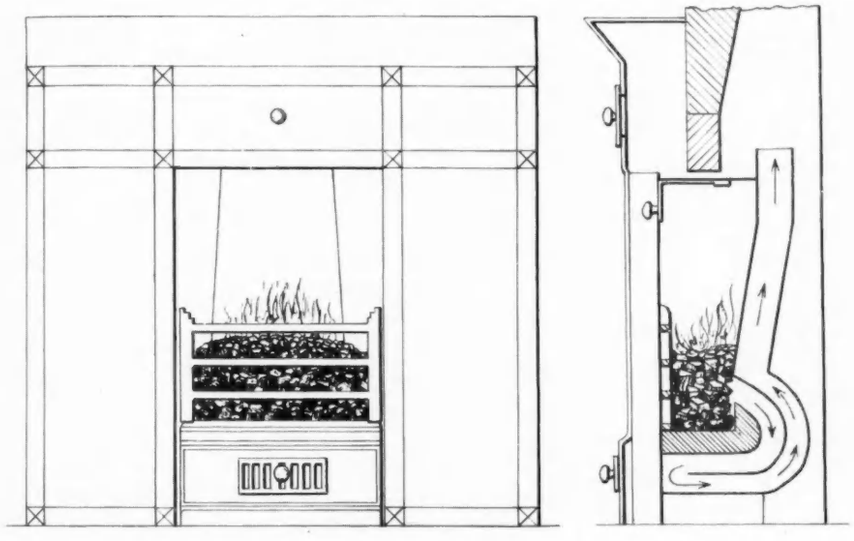


Fig. 6. Class 4—Ingram's " Kaio-Kapnos " down-draught grate.

flueways. One, from the Wilson Engineering Company, consisted of an ordinary grate to the back and sides of which covering plates of iron were applied so that shallow air spaces were enclosed. As a result air was drawn down into the fuel bed and the flue gases passed up through the spaces behind the plates. A somewhat similar form of adaptation to a conventional firegrate was patented by J. S. Hales in 1932.

Two downdraught grates were tested in the *Lancet* trials of 1906. One of these, the London Warming Company's " Florence " grate, had a back flue opening from the lower part of the fireback fireback. The other, George Wright's " Tandem " stove, had three flues behind the fireback. Then, when the fire was fully established, the flue gases passed through the central flue down to the closed ashpit, and were then drawn out through the two side flues to the chimney.

DISCUSSION

The descriptions which have been given of the various appliances developed go far to show why smoke-reducing fires have never achieved more than a limited success. It is obvious that the grates themselves fall short, and in some

Underfed grates of Class 2 are more effective in smoke reduction, and they generally give bright and attractive fires since the burning fuel is on top. But they depend for their action on the passage of the volatile matter through what must normally be only a thin layer of red fuel. This, except in the Arnott-type grates, depends upon the householder refuelling the fire at the right time and with sufficient skill to leave an effective fire on top of the raw coal. All grates of the class embody some form of mechanism, which must at best be a nuisance to the user and at worst a potential source of break-down. This is especially the case in the Arnott-type grates which, in addition, are heavy and ugly in appearance and cannot be re-fuelled while the fire is alight; if, for any reason, the charge in the coal-box proves insufficient for the needs of the day, it is necessary to clear the grate out and start again. The user can only exercise a limited control over the rate of burning of fires of this class.

Downdraught burning is theoretically a sound way of reducing smoke, though those fires of Class 3 which have been described cannot have had the maximum effectiveness since there is scarcely any attempt to introduce preheated secondary air at the point of combustion. The main combustion takes place at the back of the fuel bed, so there is a considerable danger that not only will the direct radiation be reduced due to chilling of the outer surface of the fuel by the cold air drawn into it, but that much of the heat will go to waste. Indeed, the Jurors of the 1882 Exhibition condemned the downdraught fire as " wrong in principle," going on to say that " the heat derived from this part of the combustion must, therefore, be wasted unless it can be utilised to heat air or water." In general fires of this class tend to burn at a high rate on downdraught. The rate of combustion can only be reduced by increasing the proportion of updraught, which leads to a loss of effectiveness of smoke reduction.

The coking and hopper-fed grates of Class 4 are potentially very good smoke reducers if two requirements can be fulfilled. Firstly, there must be adequate arrangements for the volatile matter distilled off from the fuel in the hopper to be burnt usefully. Secondly, it must be possible for the partially carbonised material in the hopper to be extracted with ease and transferred to the fire. In practice it seems unlikely that such fires could handle coals with any degree of swelling power, and in any event there is always a likelihood that heavy tarry deposits will occur in the hopper and connecting ports. There is a danger too that the fire will spread back and ignite the whole mass of the fuel in the hopper. The degree of controllability appears reasonably good, in general, and there is no reason why the fire should not be attractive.

Thus it appears that the inventor of this type of fire has been faced with both technical and social obstacles in his attempts to enlist the interest of the public. He has found it difficult to produce a grate which is truly effective in its smoke-reducing qualities, while the better the smoke reduction then generally the poorer the heating performance. Yet he has not been able to produce any clearly definable compensating factors with which to off-set these factors. Rather the contrary, since those designs which have been best as regards smoke have generally had some positive disadvantages. They have had to incorporate some mechanism or gadget which could go wrong, or demanded some special skill or novel technique in operation, or were clumsy in appearance, or had a limited control of burning rate, and sometimes all of these things.

In the light of the information available at the time it is consequently not surprising that the Committee on Air Pollution came to the conclusion that " . . . at the present time there is no prospect of producing an open fire, or a stove which could take the place of an open fire, capable of burning bituminous coal smokelessly." This does not mean that it cannot be done, and it is to be hoped that continued efforts will be made to find a solution to the problem. While the Committee thought primarily in terms of true smokelessness, the potential importance of a partial solution should not be overlooked. An appliance with an attractive appearance and a good heating performance, capable of burning bituminous coal to give one-third, or even one-half, of the normal smoke emission, provided that this action was automatic and not dependent upon special skill and handling by the user, would have a great value to the community.

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BIBLIOGRAPHY

" Report of the Parliamentary Commission on the Warming and Ventilation of Dwellings." House of Commons Accounts and Papers, 17, Section II, 1857.

Our Domestic Fire-Places by F. Edwards. Longmans, Green & Co., London, 1870.

Official Report of Smoke Abatement Committee, 1882. Smith, Elder & Co., London, 1882.

" Tests of Domestic Open Fire-Grates." *Lancet*, 10 May, 1902; 20 February, 1904; 19 May, 1906.

Atomic Review

Three Questions

DR. NORMAN HILBERRY, Director of the Argonne National Laboratory, has recently been in England. The answers to three questions put to him by ENGINEERING are given below, together with certain other comments which he made. His main observations referred to boiling-water and gas-cooled reactors; subsequent notes are also concerned with these systems. References to Geneva papers and other sources are given at the ends of notes where appropriate.

1. Instability in Boiling Reactors

Question: At one time it was considered that instability due to the irregular formation of steam voids in the reactor core represented a serious disadvantage of the boiling-water system. Has this problem been solved? Or has it in fact proved unreal?

Dr. Hilberry: The problem has turned out to be unreal; the statistical distribution of the steam voids is such that operation over the whole core is effectively uniform.

2. Boiling Heavy Water

Question: Are there any special snags in boiling heavy-water reactors, apart from the cost of heavy water?

Dr. Hilberry: No. Boiling-water reactors cooled and moderated by heavy water are much the same as those using ordinary water—they suffer from bad plumbing. You can never be sure whether you are transferring heat from one circuit to another or just water. But in the case of heavy water this can be expensive.

3. Gas-Cooled Reactor Invitation

Question: The United States Atomic Energy Commission have recently invited proposals for the design and construction of a 30 to 60 MW (electrical) prototype gas-cooled power reactor, with the interesting proviso that gas-outlet temperature should be in excess of 1,000° F (538° C). (See Atomic Review last week.) Is this invitation open to British companies?

Dr. Hilberry: Probably not. The USAEC offer does not expressly forbid overseas companies to tender, but it's pretty unlikely that they would get the contract. Yes, the temperature is pretty high: the way we figure it, there's no point in just tagging along behind the gas-cooled band wagon; other people have beaten us to it. If we're to do anything worthwhile, we've got to try for something better. (The fuel surface temperature in the Advanced Gas-Cooled Reactor—AGR—now under construction in Britain is to be 600° C, giving bulk gas-outlet temperatures of between 500 and 570° C.)

Superheated Steam

The boiling-water reactor made no economic sense without superheating, said Dr. Hilberry in answer to another question. Nuclear superheating had been studied at Argonne but so far they hadn't got the answer. It disturbed his aesthetic sense to have an oil superheater, but until the nuclear boys could think of something better, an oil superheater it would have to be. What did he think of the Russian superheated steam reactor? Well, as far as he could see, the way the Russians operated was to build first and count the cost afterwards. They chucked in tons of stainless steel and then made up the neutron losses with enormous enrichment. Sure they had a superheated steam reactor, but at what a price!

Spray Evaporation for Boiling Reactors

In an attempt to overcome the adverse effects of the formation of steam voids within the reactor core and an associated roughness of power level characteristic in the normal type of boiling-water reactor, a method of steam generation has been devised in which the relative positions of the liquid and vapour phases are reversed. In this process, termed " spray evaporation," the liquid phase is dispersed in the steam instead of the reverse. The coolant can thus be regarded as a suspension of liquid droplets carried in an inert carrier gas or in their own vapour.

Preliminary heat transfer rates and pressure-drop data have been determined for a steam-water system at substantially atmospheric pressure in an electrically heated test section for various steam qualities, total flow rates and heat fluxes: these heat transfer coefficients lie within the range 5,000 to 10,000 B.t.u. per hr sq. ft °F depending on the operating conditions employed. Such a system, therefore, offers an attractive alternative to both gaseous and liquid coolants for nuclear reactors since not only does it minimise the undesirable nuclear properties of a single-phase light-water coolant, but also enables heat-transfer coefficients to be achieved of the same order of magnitude as those obtained with liquid-metal systems. A two-phase system for a heavy-water moderated reactor using as coolant either light or heavy water in conjunction with its own vapour is shown diagrammatically in Fig. 1. (H. R. C. Pratt and J. D. Thornton—AERE—*Spray Evaporation: a New Method of Steam Generation and its Possible Application to Boiling Reactors*, Geneva P1451, UK.)

Gas-Cooled Reactor Conference in USA

A two-day unclassified conference to review the United States Atomic Energy Commission's gas-cooled power reactor programme will be held at the Commission's Oak Ridge National Laboratory, Oak Ridge, Tennessee, on 21 and 22 October. This programme includes design and development of five gas-cooled reactor types: prototype graphite-moderated reactor recently authorised by Congress, pebble-bed reactor, heavy water-moderated reactor, high-temperature process heat reactor and maritime propulsion reactor. Proceedings are to speakers from the Commission; Kaiser Engineers; ACF Industries; General Electric Company, Hanford; Oak Ridge National Laboratory and General Nuclear Engineering Company; Sanderson and Porter; General Atomic Division of General Dynamics Corporation; and the United States Bureau of Mines.

American Gas-Cooled Reactor Study

The preliminary design of a natural uranium graphite-moderated carbon dioxide cooled reactor and power plant similar to, but larger than, the Calder Hall plant, with a net electrical output of 130 MW (electrical) has been evaluated by members of Atomics International. The design is conventional, consisting mostly of standard components, the only major uncertainty being the performance of the fuel cladding. A construction cost of $67 million and a power cost of 17 mills per kWh are estimated for this plant, assuming private utility operation in the United States, which is about three times the cost of power from conventional plants. Power output and cost for various conditions of temperature and pressure, and for increased reactor size, are calculated. It is estimated that a similar plant of 740 MW (electrical) would produce power at a cost of 10 mills per kWh. Use of helium as coolant has been investigated and found to offer no advantage over carbon dioxide (W. F. Banks, G. A. Schneider, W. T. Morgan and E. B. Ash, Atomics International Division, North American Aviation Incorporated, Canoga Park, California, as reported in *Nuclear Science Abstracts*.)

American 44 MW Gas-Cooled Reactor Study

A feasibility study and cost estimates for a gas-cooled, partially enriched uranium, graphite-moderated 44 MW (electrical) power plant have been prepared by the Henry J. Kaiser Co. of Oakland, California. The plant is designed as a prototype of a 220 MW (electrical) plant comprising four adjoining buildings housing reactor, turbine generator, warehouses, and offices. Facilities include the induced-draught cooling tower, a substation, and necessary utilities. The estimated costs of the 44 MW prototype are: design and construction $960 per kW (gross electrical) and power produced 32 mills per kWh of which fixed charges are 25 mills per kWh. Outlet gas temperature and pressure of 1,000° F and 387 lb per sq. in give a net thermal efficiency of 35·3 per cent. The degree of enrichment is selected to provide an average fuel-element lifetime of 10,000 MWd per metric ton. (Kaiser Engineers Division, Henry J. Kaiser Co., Oakland, California, and Nuclear Products-Erco Division, ACF Industries Incorporated, Washington, DC, reported in *Nuclear Science Abstracts*.)

American 215 MW Gas-Cooled Reactor Design

A feasibility study and cost estimates for a gas-cooled partially enriched uranium graphite-moderated 215 MW (electrical) power plant optimised for minimum power cost have also been published by Kaiser. The plant consists of one multi-purpose building which houses the reactor plant, turbine generator, warehouses and shop. Other facilities include an office building, river pump house, substation and necessary utilities. The estimated costs are: design and construction $410 per kW (gross electrical) and power produced 15 mills per kWh, of which fixed charges are 12 mills per kWh. The 2·5 per cent enrichment is selected to provide an average fuel-element lifetime of 10,000 MWd per metric ton. The outlet gas temperature and pressure of 1,000° F and 370 lb per sq. in give a net thermal efficiency of 35·8 per cent. (Kaiser and Nuclear Products-Erco as above, reported in *Nuclear Science Abstracts*.)

Stability in Gas-Cooled Reactors

The problem of stability in gas-cooled reactors of the Calder Hall type was discussed by Sir John Cockcroft in a lecture " Recent Developments in Nuclear Engineering " delivered before the Danish Society of Civil Engineers on 6 October.

Initially with a new charge the temperature coefficient of reactivity associated with increases of fuel-element temperature and moderator temperature are both negative and the system

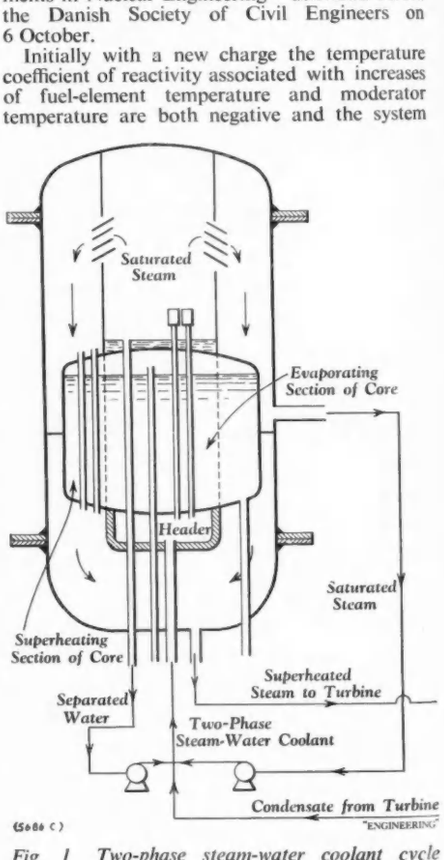


Fig. 1 Two-phase steam-water coolant cycle for a proposed heavy-water moderated reactor.

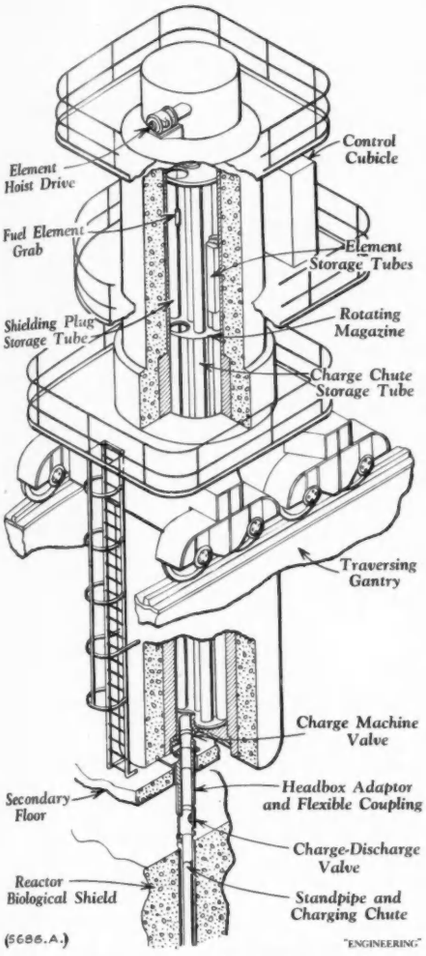


Fig. 2 Charge machine for the Bradwell nuclear power station being built by the NPPC.

is entirely self-stabilising. As the radiation of the fuel proceeds, the increasing quantity of plutonium fuel modifies the delayed temperature coefficient associated with the moderator temperature making it increasingly positive, but the prompt coefficient of temperature associated with the fuel-element temperature remains negative. After an irradiation of about 400 MW days per ton, the moderated temperature coefficient is about $+ 4 \times 10^{-5}$ k per deg. centigrade. It is expected to reach a saturation level of about 15×10^{-5} with very long irradiation. The overall effect of this limiting value of the temperature coefficient would be that small increases in power level could be doubled in a time of about two minutes if no control-rod movement were made to correct this. So after a thermal power level change of 200 to 201 MW, the level would increase to 202 MW in two minutes and to 204 MW in four minutes. These are very slow changes compared with the time in which the control rods could operate to correct the fluctuation.

Fuel Ratings

Fuel ratings in MW per ton given by Sir John Cockcroft in his lecture are as follow: Calder Hall 1·4; Hinkley Point 2·6; AGR 8.

Charging on Load at Bradwell

In the nuclear power station being built at Bradwell by the Nuclear Power Plant Company, a system for charging and discharging fuel on load from the top of the reactor has been adopted for several reasons.

1. All access to the reactor is from one working floor.

2. No auxiliary parts are required permanently inside the reactor vessel.

3. Control rods and other equipment at the top of the reactor can be handled by the same universal machine.

4. The position of the charging equipment is consistent with a very low reactor which is desirable for thermodynamic reasons.

5. The overall cost of a top charging system is considerably less than other systems.

New fuel is stored on the first and second floors of one face of the reactor building. Elements are loaded into a 32-way magazine in a room immediately below the pile cap, and the charge machine lifts them from the magazine through a vertical pipe by remote control. The charge machine is a tubular pressure vessel, heavily shielded, the overall height being about 55 ft. It is supported on a gantry running on rails across the pile cap and can be accurately positioned over any of the 256 standpipes on the reactor vessel. There is space inside the machine for new and spent fuel, a charging chute for insertion into the reactor vessel, and two standpipe shielding plugs, all to be handled by two internal hoists. An internal view of the machine is shown in Fig. 2. There are 88 refuelling standpipes on the top of the reactor, each serving 34 fuel channels. The remaining 168 standpipes are for control rods, fission-product detection equipment and other mechanisms requiring to be inserted into the reactor. Each refuelling standpipe is equipped with a power-operated valve at the top and a removable shielding plug below this valve. The charge machine can be connected to any standpipe by removing a floor slab and fitting a headbox adaptor. A flexibly mounted coupling on this adaptor connects it to the charge machine, thus taking up errors in alignment so that only small loads can be imposed on the reactor vessel.

The charge machine, once connected to the standpipe, is remotely controlled from a room which commands a view of the whole pile-cap area. The service hoist can remove the shield plug from the standpipe, place it in store in the vessel and insert the charging chute into the standpipe, as indicated in Fig. 3. The machine then has direct access to the core. Intense neutron and gamma radiation passes up the unplugged standpipe, but the shielding on the machine reduces the scattered radiation to less than 4 mrem per hr in its vicinity during operation. By orientation of the charging chute and operation of the electrically-driven fuel hoist, the fuel may be changed while the reactor is at full power. The chute is then removed, the shield plugs re-inserted, the valve closed and the machine disconnected. (R. D. Vaughan and E. Anderson—NPPC—*Bradwell Nuclear Power Station*, Geneva P263, UK.)

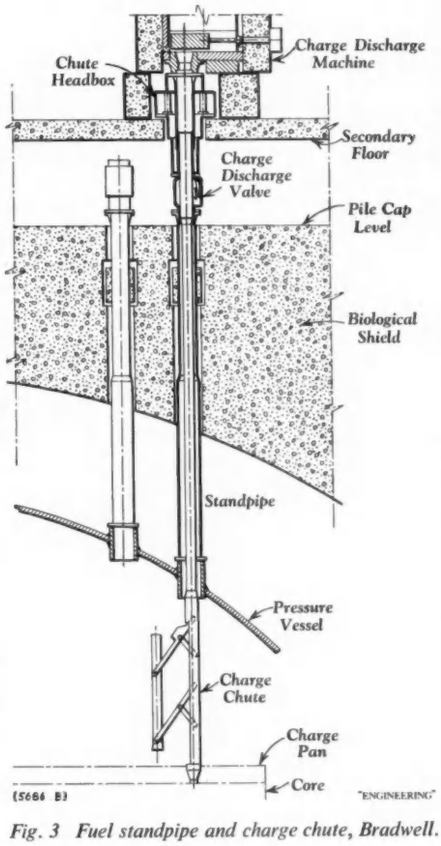


Fig. 3 Fuel standpipe and charge chute, Bradwell.

Notes and News

Britain and Euratom

Mr. Arthur H. Tandy, C.B.E., United Kingdom representative to the European Coal and Steel Community, has presented his credentials to the Commission of the European Atomic Energy Community in his new role as United Kingdom representative to Euratom. Mr. Tandy succeeds Sir William Meiklereid, K.B.E., C.M.G., who has retired from the Foreign Service. Like Sir William, he will have the rank of ambassador. The British Government announced on 22 May that it proposed to appoint a diplomatic representative to Euratom. The British Government announced at the same time its intention to open negotiations with a view to reaching an agreement for co-operation between the United Kingdom and Euratom on the pacific use of nuclear energy. These negotiations are now under way and the agreement is expected to be reached some time this autumn.

Proceedings of CERN Conference

The 1958 annual International Conference on High Energy Physics was held at CERN in Geneva from 30 June to 5 July. The *Proceedings* of the conference have now been published by CERN. The conference was the eighth in a series of annual conferences on high-energy physics, of which the first seven were held at the University of Rochester in the United States. These annual conferences are now regulated by the Commission on High Energy Physics of the International Union of Pure and Applied Physics, which has decided that the next three conferences will be held in Moscow (1959), Rochester (1960) and Geneva (1961).

There were nine sessions, devoted to nucleon structure, the nucleon and its interaction with pions, photons, nucleons, and antinucleons, fundamental theoretical ideas, strange particle production, strange particle interactions, special theoretical topics, weak interactions: leptonic modes, and weak interactions: other modes. The final session was devoted to concluding remarks by Professor J. R. Oppenheimer. One of the highlights of the conference was the animated discussion in the session on fundamental theoretical ideas on Professor W. Heisenberg's proposal of a unified theory of elementary particles on the basis of a non-linear spinor theory of matter.

Soviet 600 MW Station

The first Soviet large-scale nuclear power station came into full operation on 7 September. It comprises 6 identical 100 MW (electrical) reactor units of graphite-moderated water-cooled design. The reactors, fuelled with natural uranium, incorporate stainless-steel pressure tubes, and steam reaches the turbines at 90 lb per sq. in and 185° C.

Contractors for the AGR

It is reported that Whatlings, the civil engineering contractors, have been awarded a contract for the Advanced Gas-Cooled Reactor under constuction at Windscale in Cumberland.

FBI Conference Report

The Federation of British Industries has published a report of the conference on nuclear energy held by the FBI in Eastbourne last April. The conference was reported in Atomic Review last 25 April. Copies may be obtained from the Federation at 21 Tothill Street, London, S.W.1, price 15*s*.

Automobile Engineering

QUALITY CARS

ARMSTRONG SIDDELEY STAR SAPPHIRE

The Armstrong Siddeley Star Sapphire will take its place among the luxury cars at the Motor Show. With a 4-litre engine it can reach 92·5 m.p.h. in top gear without the piston speed exceeding 2,500 ft per min. The quoted performance is 3,178 litres per ton mile dry. The car weighs 35½ cwt with a full tank. The standard saloon model is fitted with Borg Warner automatic transmission, Girling disc front brakes and Burman power steering. There are independent heating and ventilating systems for the front and rear seats (including rear window de-misting), a cigar lighter on the facia panel and ultra-violet lighting for the instruments. Even the luggage boot is lined with carpet.

The all-steel body is fitted with curved windscreen and safety glass throughout. Visibility is good and both wings can be seen from the driver's seat. Burr walnut is used for the facia and interior woodwork. In both front and rear compartments the centre and side armrests are folding, and those at the front are adjustable. The front doors, which have forward concealed hinges, also have concealed pockets, and there are pockets at the back of the front seats. There is a separate compartment for the spare wheel and a rubber lined tool drawer. The body is sound proofed and the floors are carpeted; twin roof lights operate when the doors are opened. There are also automatic under-bonnet and boot lights. The finish can be in any one of nine colours, or in any combination of them, and the leather upholstery can be supplied in eight shades or, again, in any panelled combination of them.

The engine has a bore and stroke of 97 mm. by 90 mm. respectively—making it "over square." This gives a capacity of 3,990 cc, working at a compression ratio of 7·5 : 1. The RAC rating is 35 h.p. but the engine develops 165 b.h.p. (gross) at 4,250 r.p.m. and a maximum torque of 230 lb-ft at 2,000 r.p.m. Fuel is supplied by an AC pump feeding through two Stromberg down draught carburettors. The fuel tank holds 16 gallons with a reserve of 2 gallons. The four-bearing crankshaft runs in indium lead bronze main bearings with pressure oil feeds, and there are also pressure oil feeds to the big ends, timing chain, and rocker gear. The cooling system contains a pump, fan and thermostat. The overhead inclined valves are operated by tubular push rods from a single camshaft. The engine is mounted on rubber—a single point at the front and two points at the back.

Transmission is by fluid torque convertor and Borg Warner automatic box giving overall ratios from 3·77 : 1 (direct top) to 17·35 : 1 (low, with full torque multiplication). The gear lever is on the steering column and there is a control to hold the intermediate range mounted on the instrument panel. An open two-piece centre-bearing shaft drives the hypoid rear axle, which has a ratio of 3·77 : 1.

The chassis frame is a box section with tubular and cruciform cross bracing. Brakes are Girling hydraulic, disc at the front and drum at the rear, with Vac Hydro servo and vacuum reservoir. The foot brake operates hydraulically on all four wheels, but the pistol-grip hand brake works on the rear wheels only. At the front the suspension is independent coil springs with trailing wishbones and anti-roll bar, while semi-elliptic springs are used at the rear. Armstrong telescopic dampers are employed. Smith's Bevelift jacks work on four points on the chassis.

The car has a turning circle of 38 ft and wheelbase of 9 ft 6 in; the track is 4 ft 9⅞ in. Overall length is 16 ft 2 in; width 6 ft 2 in, and height 5 ft 2 in. Dunlop 6·70 by 16 tubeless tyres are fitted. The basic price is £1,763, plus £882 17s purchase tax.

This 6-light saloon has a top speed of 92·5 m.p.h.

Alvis saloon with the new Swiss-designed body.

NEW ALVIS 3-LITRE

The Alvis 3-litre has a new body built by Park Ward, London, to designs by Graber of Switzerland. The chassis and the six-cylinder pushrod engine of 2,993 cc, developing 104 b.h.p. with a compression ratio of 8·0 to 1, have only minor changes—chiefly a gearbox with slightly different 1st and 2nd gear ratios a little more widely spaced.

There is a choice of four-light, two-door saloon or convertible; coachwork furnished in leather; large built-in luggage accommodation with spare wheel container below, having separate access; separate front seats, adjustable for reach. The equipment includes Smith's heating and ventilation system.

Dimensions: wheelbase, 9 ft 3½ in; track front, 4 ft 6⅝ in, rear, 4 ft 6 5/16 in; Overall length, 15 ft 9 in; overall height, 5 ft 0 in; overall width, 5 ft 6 in; ground clearance, 7 in; turning circle, 39 ft 6 in; Max. speed, over 100 m.p.h. Basic prices in England: saloon £1,995; drophead, £2,195.

JAGUAR MARK IX

An addition to the Jaguar range that will make its debut at the Motor Show is the Mark IX saloon. It has the same outward appearance as the Mark VIII (which, with the rest of the present range, will be continued) but is to be fitted with a 3·8-litre engine, as against 3·5 litres for the Mark VIII. Other changes will be the use of Dunlop disc brakes on all four wheels and the inclusion of power-assisted steering.

The engine develops 225 h.p., which is 15 h.p. greater than the 3·5-litre model, giving the car increased acceleration in the lower and medium speed ranges owing to the improved torque obtained. The maximum speed will be in the region of 110 m.p.h. Three versions are available; with standard gearbox; with automatic drive; or with overdrive. The basic price of the first is £1,329, plus £665 17*s* purchase tax.

Other models in the range are continued with only detailed changes. However, the XK150 open two-seater, hitherto reserved for America, has now been released for the home market.

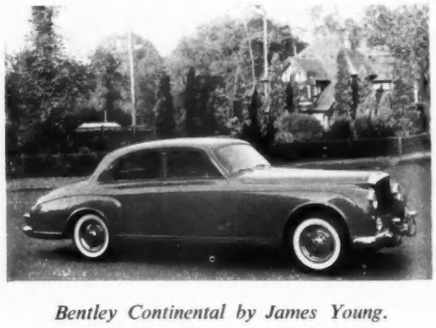
ROLLS-ROYCE AND BENTLEY

As well as the standard Rolls-Royce Silver Cloud and Bentley "S" cars which will be seen at the London Motor Show, there will be several interesting coachwork exhibits, and for the first time for many years, there will be a Rolls-Royce with drophead coupé body.

This will be a Silver Cloud shown by H. J. Mulliner with the body in whitehall grey over rose beige and red hide upholstery. There will be a Rolls-Royce with the 127 in long wheelbase with a division fitted by Park Ward, and a Silver Wraith seven-passenger limousine on 133 in wheelbase, also with coachwork by Park Ward.

In addition, Park Ward are exhibiting two Continental Bentleys, one saloon and one drophead, and there will be the Continental by H. J. Mulliner, the Flying-Spur four-door saloon.

All Rolls-Royce and Bentley chassis now have the same engine, the six cylinder unit of 4,887 cc. The gearbox is fully automatic, brakes are servo assisted, chassis lubrication centralised and ride control of the rear shock dampers fitted as standard features. Optional extras include power assisted steering at a basic price of £110. Refrigeration (air conditioning) £385 basic and Rolls-Royce electrically operated windows at a basic price of £65.



Bentley Continental by James Young.

The Human Element

Elements of Goodwill

Six essentials have been given as basic to good human relations and effective management within a company. They were listed by Thomas Hedley and Company Limited (who employ 3,700 people in their factories) in their annual general statement published recently. The first is "to be successful" and this is a responsibility of the management: "only a successful company making a healthy profit can continue to pay wages and expand its business, thereby creating new jobs, new products, wider opportunities for its people and an increasing standard of living for the community at large." All the others are also company responsibilities: guaranteed employment, a fair day's pay for a fair day's work, good working conditions, adequate protection in time of need, and opportunity to advance on merit.

Hedley's do not accept the inevitability of fluctuating employment. They make it their business to take steps necessary to keep employment steady by organising their marketing activities and their sales promotion in such a way that their products are consumed regularly throughout the year. Each of their hourly paid workers who has been with the company for two years or more, since 1947, qualifies for a guarantee designed to provide him with regular employment for the rest of his working life.

Pay is based on job evaluation and compares favourably with salaries and wages paid "for similar types of work by leading companies" in the communities in which Hedley operate. Working conditions are constantly the subject of research, with the object of promoting goodwill "and personal satisfaction in work," good health, and safety. There is insurance in plenty—a voluntary sickness fund for factory workers to which the company make matching contributions, a group life-insurance plan and a contributory pension fund which contains a profit-sharing scheme. Finally, there is the policy of making all promotions from within open to all (40 per cent of the total management group came from hourly workers). Nevertheless, for 25 years, Hedley's have recruited straight from the universities for their staff and management.

Way of Life

E. I. du Pont de Nemours and Company, who employ 85,000 in many locations throughout the United States, have just published the results of a survey of their employees in their magazine *Better Living* (Sept-Oct 1958). Over 3,000 of the company's employees have replied to some 80 questions on their way of life, material standards, ambitions, worries, hobbies and off-work interests, and the results are compared with similar surveys of 1948 and 1953. The "typical US industrial worker," state du Pont, has made "dramatic economic gains" in the last 10 years, and these have been balanced by their various social advances. There has been a sharp increase in the ownership of houses, cars (85 per cent of the under twenty-fives run a car) and savings, but also a considerable advance in cultural and spiritual interests. Nearly half of all age groups attend church regularly, many contribute to charities, interest themselves in community needs, are enthusiastic in favour of more education for their children, and so on.

Worries exist, but the typical American worker does not seem to concern himself very much with racial problems or corruption in Government circles, nor does he worry about his or her job. World unrest is the main cause for anxiety, and taxes come next. Security and a good education for children are the main desires; health and happiness the principal dreams for the future.

The typical du Pont man is between 25 and 40, and has been more than 10 years with the company but has been on his present job less than five years (job changing is company policy to stimulate interest in work, and is encouraged). He is a high-school graduate (76 per cent have high-school education or better), is married, has 2·2 children (1·4 in 1948), a six-room house which he is buying, and a variety of off-job interests, including football, fishing and gardening. The du Pont woman is in the same age bracket, similarly educated, but has less than 10 years' service. Sixty-one per cent are married and 55 per cent work in offices. Much of this seems to point to greater maturity and seriousmindedness.

Practical or Academic

The question of the teachability of management techniques has been raised once again in a report by the University Grants Committee called *University Development 1952-1957* (HM Stationery Office, 5*s* 6*d*). The report makes the important point that the emphasis which is often put on the essential post-graduate nature of management instruction (mostly so because candidates for such instruction tend to be older men with some practical experience) is apt to blur two separate issues.

There are in fact two kinds of "post-graduate" courses to be considered. The first is a course for those who need instruction to apply what they learn to the practice of management in their careers. The other is for those who will go on to do research into management techniques. The report goes on to say that these problems of developing management techniques as an academic discipline constitute a worthwhile challenge and that a number of universities are trying to develop both their research and training work in this direction.

Concentrated Solution?

The shortage of chemical engineers is well known. The Institution of Chemical Engineers has now issued a report called *A Survey of Output of Chemical Engineers*, which gives an analysis of their employment by region, by industry and by occupation.

The Institution estimates that the population of chemical engineers in 1956 to cover industry's requirements should have been 5,000 against an actual figure of 1,500. The numbers required by 1966 are about 10,000. The survey shows that the regions with the largest populations of chemical engineers also have them concentrated in a few establishments and that the problem of shortage cannot be solved by confining the chemical engineers available to a few regions. When analysed by employment it is found that an increasing number of chemical engineers are engaged on administration and fewer on plant operation. Compared with the United States, the proportion employed on research and development is still low. On an industry by industry basis, the greatest concentration was found in the oil industry. This is not surprising since the output per employee in this industry is particularly high.

Asking Questions

The Nuffield Foundation's annual report for the year ended 31 March, 1958, includes references to work carried out at the London School of Economics into question-and-answer techniques in social-science work. It has been known for a long time by those who have had to use the questionnaire procedure that its claim to scientific validity is a tenuous one. This is inevitably so for it deals with the reaction of human personality to a direct question and a host of variable factors immediately come into play.

The unit at work at the School is now concentrating on four studies. The first of these is the design of questionnaires. This is clearly basic, for if the questions are not correctly posed and presented, the rest of the exercise is basically adrift. Particular attention is being given to the memory factor. The second problem under review is to find ways of checking answers from unbiassed sources. Thirdly, an effort is to be made to find how far the reactions between interviewer and respondent influence the answers to questions. Finally, work is in progress on attitude and motivation in answering.

The problem of removing bias from answers is a difficult one. In one direction the answer seems to be towards greater clarity of questions but this immediately throws the complete burden of accuracy on the human reaction and it is the complex factors behind this which have so far failed to yield to research, at least so far as its practical application to interviewing is concerned.

Cost of Faring Well

The engineering industry spends less on welfare amenities for its employees than the food manufacturing industry. A progressive British engineering firm may well spend the equivalent of an additional 12 per cent to the annual wage and salary bill, compared with nearly 18 per cent for a representative food manufacturing firm. The figure of 12 per cent covers medical services, canteens, sports and social clubs, sick pay, pensions, holidays, protective clothing, works magazines, national insurance and common law insurance.

A most comprehensive survey of this type of expenditure was carried out by the Industrial Welfare Society and is published in book form as *The £ s d of Welfare in Industry*, by William Durham (7*s* 6*d*). Fifty-five firms took part, being a representative selection of British manufacturing industry, with the major emphasis on the engineering and food industries (21 of the total number were engineering firms).

The survey revealed that welfare amenities go with good pay—in engineering there was a direct correlation between wages and benefits: the higher the pay, the better the benefits. The IWS booklet constitutes a most useful guide, with a comparison of the total cost to employers of wages and welfare charges in Western Europe.

Spectre

Both the number and proportion of people unemployed rose between 11 August and 15 September. During that period, the number of people out of work increased by 30,000 and the proportion from 2·0 to 2·2 per cent. In September, 1957, the proportion of persons unemployed was 1·2 per cent. At 15 September this year, there were 416,000 persons wholly, and 60,000 temporarily, unemployed. Among the unemployed, 193,000, or 46·6 per cent, had been out of a job for more than eight weeks.

The same trend towards a slackening in industrial activity was indicated by the statistics of unfilled vacancies and short-time and overtime working. The number of vacancies notified to employment exchanges but remaining unfilled at 10 September was 179,000—24,000 less than in August. Short-time had risen slightly and overtime decreased. In the week ended 23 August, the number working overtime was 1,196,000, some 96,000 less than in May and 338,000 less than a year ago.

There is every likelihood that the situation will get worse over the next few months, if only because the hoarding of labour is growing less.

Design

WIND LOADINGS ON FLAT-ROOFED BUILDINGS

By C. Salter, M.A. *(National Physical Laboratory)*

Experiments in a wind tunnel on a model of a building having a 6° monoslope roof show that extremely high suction forces may arise locally on the roof top for certain directions of the approaching wind; also that quite large areas of the roof may be affected by suction loadings considerably greater than any normally envisaged. Typical measurements are recorded, and the conical-vortex flow pattern responsible for the high loadings is illustrated and discussed; various aspects of experimentation, analysis and application are also considered.

ALTHOUGH much general experimental evidence is already available on wind loadings, it often does not include the particular information required for the estimation of the wind loading on new structures. This is partly because many new structures are designed around a basic shape not previously considered, and partly because the variations of detail are often important. Furthermore, the effect of wind direction has not, in general, been taken adequately into account in the past. At the same time, the wind exposure to be expected (based on the local meteorological and topographical conditions) and the "shielding" effects of neighbouring buildings etc, frequently cannot be estimated with adequate reliability.

For such reasons, any new specific information that can be added to the general pool is to be welcomed. Information relating to a particular shape of building is presented here, and it is shown that very high local loadings may arise in certain circumstances. Sundry relevant matters which should assist the practical application of such experimental results are also pointed out, but the main object of the paper is to discuss the interesting type of flow pattern which gives rise to these high loadings. Qualitatively this flow pattern is common to most buildings, the differences being mainly variations of degree and of location of the affected surface areas.

It should be pointed out that after the results of these tests had been analysed the work of Ning Chien in the United States was brought to our notice.[1] This showed that severe suction regions had already been observed, but without detailed consideration of the associated air flow.

The model is shown in Fig. 1. It consisted basically of a hollow wooden box fitted with a metal cover $\frac{1}{8}$ in thick and having a 6° slope. The cover was thickened around the edges by strips of wood; it was also split transversely in various places so that one section, $4\frac{1}{2}$ in wide and carrying seven pressure tapping tubes, could be located in different positions in turn, so as to extend the pressure exploration to any part of the roof as required. The total of the measuring stations for one half of the roof is indicated in Fig. 1;

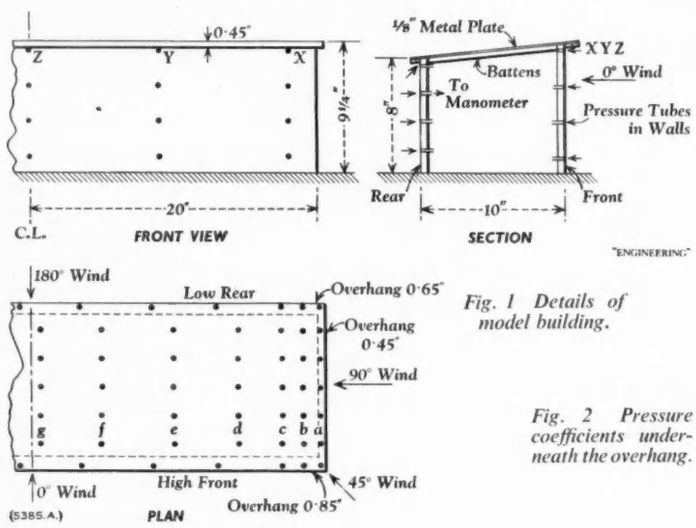


Fig. 1 Details of model building.

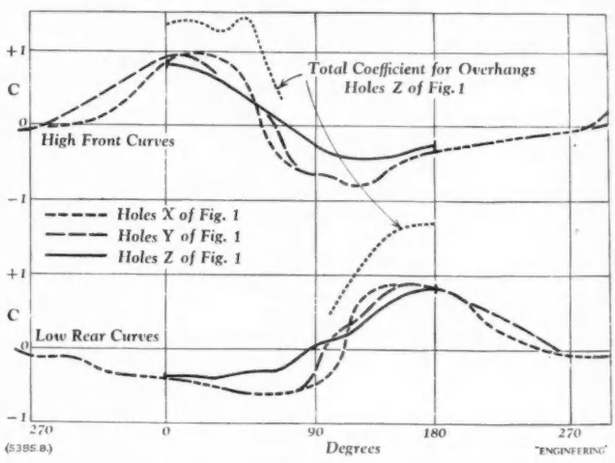


Fig. 2 Pressure coefficients underneath the overhang.

inserted in each wall there were in addition 12 tubes as shown. The box was virtually completely sealed so that only external surface pressures, without "through-flow," were measured.

The model was set up on a turntable in a 9 ft by 7 ft open-jet wind tunnel so that, in effect, the wind direction could be varied if required through the full 360°. The pressure holes were connected to an inclined multitube manometer. So also was a pitot-static tube which was located so as to indicate the wind speed (about 35 m.p.h.) appropriate to the test position with the model removed. In view of the flat surfaces and sharp corners of the model, the reproduction of full-scale Reynolds number was unnecessary.

In general, in a natural wind the speed increases with distance from the ground, but in these tests no attempt was made to simulate this gradient. Strictly speaking, therefore, the conditions of test correspond to those special atmospheric conditions where, except for a thin retarded layer near ground level, the wind speed is the same at all heights, i.e. the gradient tends to vanish.

These conditions, however, are the more important in practice. They might be expected to arise on the brow of a hill or on a moderate windward slope, especially if assisted by a funnelling effect; also, for certain wind directions, in places not far removed from the edge of a cliff. In such cases the application of these wind tunnel results is particularly appropriate. It would be necessary, however, to estimate the actual wind speed at the site; deduction of wind loading is not here related to the p values of the Codes of Practice.

Quantitative results are given in the form of a pressure coefficient C which is the ratio between the local surface pressure (relative to the datum defined below) and the dynamic head of the stream. The datum for surface pressures is the static (or true barometric) pressure in an undisturbed region of the stream. In the open-jet tunnel used for these tests, this datum is conveniently given by the still-air pressure outside the jet. Fortunately, in the application of such results as these, this datum cancels out, but it has an importance to be mentioned later.

Dynamic head is $\rho V^2/2$ where ρ is the air density (engineering units) and V the wind speed. This also refers to an undisturbed region of the stream. In particular, in lb per sq. ft for normal air it is 0·00256 (m.p.h.)^2. Its measurement in tests of this nature is normally quite a tricky matter (even more so than that of static pressure, which is often difficult enough). This is because the distortion of the stream by a bluff obstruction is very extensive, not only on the leeside, but also upwind and sideways as well. In a wind tunnel there may not be in fact a region suitable for measurement of dynamic head (or wind speed) without the need for a significant correction factor; appropriate care is therefore required. In full-scale conditions (actual buildings) the estimation of maximum effective wind speed is even more difficult.

The pitfalls of this aspect of the subject cannot be briefly discussed, and the possibility of danger will merely be emphasised here. The maximum positive pressure that might be expected in these cases is the stagnation pressure, of a streamline. Suffice it to add, therefore, that a measured

value of C greater than +1·0 might be inherently consequent upon the definition of approach speed where tests are carried out in a non-uniform wind, or upon the selection of a purely arbitrary datum for surface pressures. Unless, however, these can be established, it should be suspected as indicating a possibly serious error in the measurement of dynamic head.

As regards the present results, the errors of measurement of the coefficients where the latter were significantly large, varied from virtually nothing to about 5 per cent. Approximate corrections have been applied where worthwhile, and any remaining errors in the results as presented are quite unimportant.

The pressure-plotting positions on the front and rear walls of the model are indicated in Fig. 1. The variations with wind direction of the pressure (or suction) coefficient C at the top holes X, Y, Z (front and rear) are plotted in Fig. 2. These curves can therefore be used as a measure of the wind loading on the underside of the overhangs at various positions and for various wind directions.

Generally the wall pressures do not vary much from roof to ground, but for some wind directions the mean pressure for any four vertically-arranged holes (Fig. 1) is somewhat different from that shown in Fig. 2. For design purposes, however, Fig. 2 can be used for the approximate estimation of the mean pressure (or suction) on the walls themselves.

WIND LOADING ON ROOF TOP

The variation with wind direction of the suction on the roof top at the centre section of the model (holes *g* of Fig. 1) is shown in Fig. 3. The curves for 0° and 180° apply nearly enough to the other lines of holes (*a* to *f*) and it will be noticed that 180° wind gives rise to more severe suction

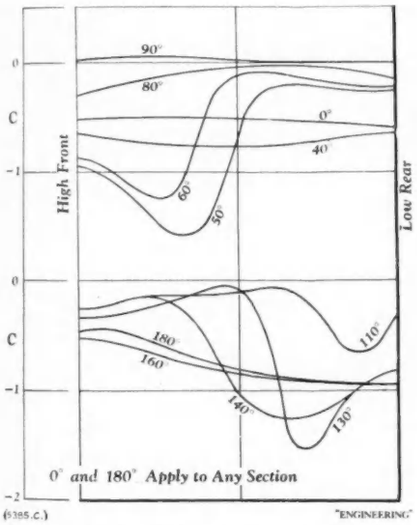


Fig. 3 Suction coefficient on roof along line of g in Fig. 1.

loading than does 0° wind.

Considering only the centre section, the total suction loading is greatest from about 40° to 60° and 140° to 180°. The worst suction loading on the windward half occurs at 50° to 60° and 130° to 140°. The maximum total lift on the overhangs (suction on top plus pressure below—small dotted curves of Fig. 2) is greatest for ranges 0° to 60° and 160° to 180°; of these two, the latter range is rather the more severe as regards loading.

It should be noted, however, that the particular curves of Fig. 3 for wind directions of say 50°, 60°, 130° and 140°, while appropriate to the centre of this model, are not automatically applicable to the centre of a longer one. Comments relevant to this are given below. Pending further evidence, however, it would be reasonable to accept them as being nearly enough appropriate for a block of rectangular planform. On a block curved in plan, it is possible that the central loading for certain wind directions would be more severe as regards distribution and would tend towards that described later for the end portion of the model.

Near the corners of the roof, the local suction loadings in corner-on-to-wind conditions were found to be extremely high. In these circumstances the natural mode of presentation of the results is that of the contour diagram now to be discussed.

CORNER-ON-TO-WIND CONTOURS

Two typical contour diagrams for corner-on-to-wind flow, reproduced in Figs. 4*a* and 4*b*, show

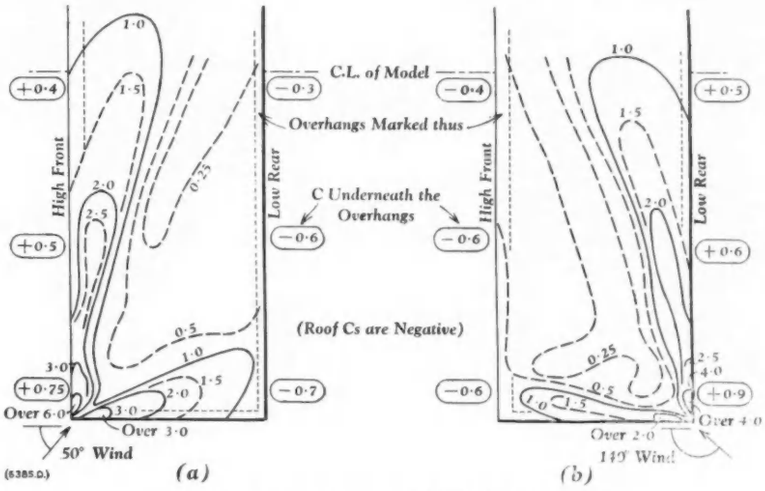


Fig. 4 Contours of suction coefficients on roof.

that the extremely high loading is restricted to small areas, but that unduly high suctions, say C > 1·5, cover quite appreciable areas. Fig. 2 shows that the positive pressure underneath the upstream overhang (also indicated in Figs. 4*a* and 4*b*) is still large, and therefore contributing to the total lift nearly as much as with 0° and 180° winds. For moderate changes of wind direction from the 50° and 140° of the contour diagrams, the change of loading is more a matter of distribution than of degree.

If one takes for the moment a unit length of roof as being that equal to the width between the high front and the low rear, it can be shown that the total loading for such a length at or near the ends of the block, in these corner-on-to-wind conditions, is not enormously greater than that on a similar length in 0° or 180° winds. The relative loadings are roughly as follows:—

Unit length, 0° wind:—2
" " 180° wind:—3
" " at end, 50° wind:—4
" " second from end, 50° wind:—3

The important significance of the contours, however, is that a large proportion of the total load may be concentrated over a relatively small area. In order that some quantitative analysis may be conveniently carried out, if so desired, the mean C's for one-inch square areas (top surface only) of the end unit length of the model are recorded in Fig. 5 for 50° wind.

Consideration of the flow pattern leads one to expect that the length of any particular high suction loop would be increased with increasing length (or width) of the model, and vice versa; there is some experimental corroboration for this[1]. It is also pointed out below that the apex of the contours could conceivably be located elsewhere along the edge than at the corner. Taking these and other factors into consideration, it begins to appear that, in design, one should cater for such high loading regions at all distances from the end of a block. The actual lift distribution for a roof depends also, of course, on such wall pressures as happen to leak through sundry apertures to the inside of the building.

The other points to note from Figs. 4*a* and 4*b* are firstly, that the suction loading near the low eaves edge in 140° wind is, say, half to two-thirds that near the higher side in 50° wind; and, secondly, that the loading along the shorter end of the roof is considerably less still. The slope of the roof and the lengths of the edges are therefore of some importance. It is not generally possible, however, to deduce double slope loading from single slope observations.

FLOW PATTERNS

Fig. 6*a* shows qualitatively the sort of large eddy set up behind a long bluff body when the

End Unit Length Top Surface Only
(Values are Negative)

1·9	2·4	2·1	0·6	0·2	0·2	0·3	0·3	0·3	0·4	0·4		
2·0	2·6	2·0	0·4	0·2	0·3	0·3	0·3	0·3	0·4	0·4		
2·0	2·6	1·5	0·5	0·3	0·3	0·3	0·3	0·3	0·4	0·4		
2·0	2·6	0·9	0·5	0·4	0·3	0·3	0·3	0·3	0·4	0·4		
2·0	2·4	0·8	0·5	0·4	0·3	0·3	0·3	0·3	0·3	0·4		
2·5	1·5	0·7	0·5	0·4	0·4	0·3	0·3	0·3	0·3	0·4		
2·5	1·0	0·7	0·4	0·4	0·4	0·4	0·4	0·4	0·4	0·5		
2·0	0·8	0·5	0·4	0·4	0·5	0·6	0·7	0·7	0·7	0·7		
2·0	0·8	0·5	0·5	0·5	0·7	0·8	1·0	1·1	1·1	1·0		
4·0	0·9	0·7	0·7	0·8	1·0	1·3	1·3	1·3	1·2	1·0		
5·0	1·0	0·9	1·8	2·0	1·9	1·7	1·4	1·2	1·1	0·9		
3·0	3·0	2·7	2·5	2·2	1·8	1·6	1·4	1·2	0·9	0·9		

Wind 50°

(5385.H.) "ENGINEERING"

Fig. 5 Local average values of C.

wind approaches normally to one of the long faces. The "static" (or local barometric) pressure inside this eddy is less than that in the undistorted regions of the stream and is determined by the concentration and curvature of the adjacent streamlines. The eddy being large, the field of distorted flow is also large, the concentration therefore fairly moderate and the "suction" inside the eddy also moderate. Because of the weak rotation, this suction is also not far from being uniform.

As the wind diverts from the normal direction this (cylindrical) eddy becomes gradually smaller and stronger. In the later stages, as in Fig. 6*b*, it sits on the front portion of the body. The field of distorted flow is now very much reduced, so that the concentration of the adjacent streamlines is much enhanced and the suction inside the eddy is therefore greatly increased.

At the centre of the eddy this is in fact now

Continuing **Design**

much larger than at its outside diameter. It is the latter, however, which determines the suction on the adjacent surface of the body. The core of the eddy nevertheless identifies the line of maximum suction on the surface being directly above it. Where the eddy is not in fact circular this line is naturally less well defined.

As the eddy size decreases from Fig. 6*a* towards Fig. 6*b* the adjacent streamlines " come to ground " with greater and greater strength, and the region " sheltered " by the body, which in Fig. 6*a* extends back beyond the actual eddy, becomes very much less.

It follows that an obstruction on the windward side of a building is not necessarily beneficial as a wind shield. It is also useful to note that an extra obstruction in the lower part of the large eddy of Fig. 6*a*, which tends to prevent the reverse flow near the ground, will *ipso facto* tend to prevent the establishment of an eddy of this magnitude and is very likely to increase the suction loadings on the main building[2].

With this background it is now possible to appreciate the flow pattern set up on the roof of the model. In Fig. 7 an attempt has been made to illustrate the main features for a corner-on-to-wind flow. Because the model is not

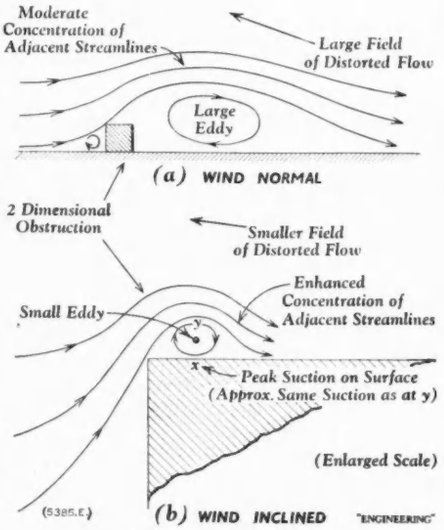


Fig. 6 Flow patterns (general).

there is always a strong surface flow in the space between the two rotary flows (Fig. 7).

DISTRIBUTION OF PRESSURE HOLES

In this type of pressure measurement the plotting of the contours is a matter of considerable uncertainty unless either a very large number of pressure holes is arranged, or else use is made of the flow pattern development. In the latter case the sort of average hole density shown in Fig. 1 is ample. Preferably the spacing should be much closer near the edges than elsewhere.

One difficulty is that of locating, for any particular wind direction, the maximum suction positions along the various lines of holes. This can be overcome by finding, for obviously important pressure holes, the wind direction for maximum C. This identifies the core of the vortex. By making use of the swing of the vortex, and by applying various forms of cross-plotting, it then becomes possible to achieve a complete analysis.

The scope of the work and the comments presented in this report cover but a small part of a large field. Nevertheless, although the numerical results can only be applied where specifically relevant, the qualitative analysis is

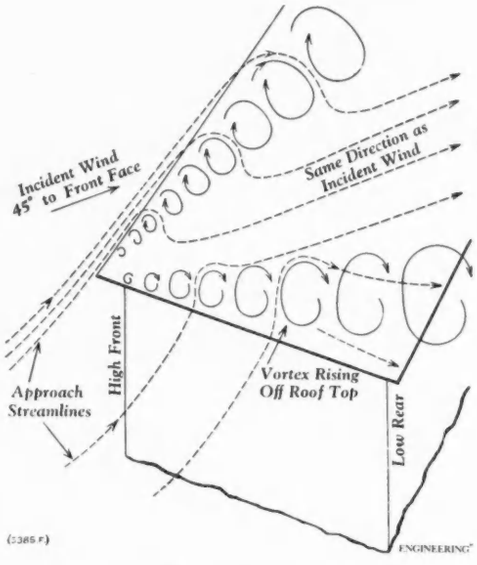


Fig. 7 Double conical vortex pattern.

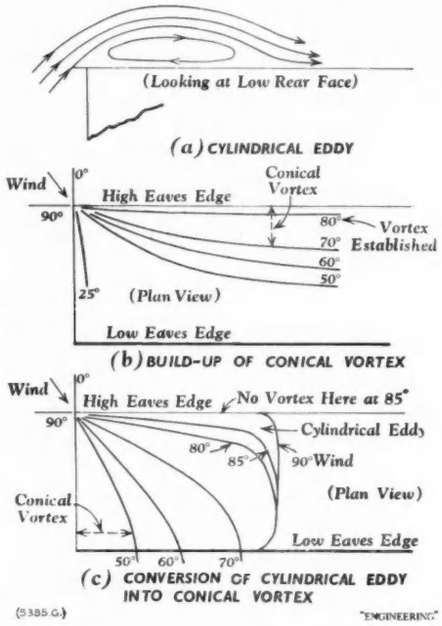


Fig. 8 Development of vortex patterns.

infinitely long, the roof eddies are not uniformly cylindrical, but start near the upstream corner as conical vortices. Some distance from the corner they settle down to more nearly cylindrical eddies and also rise off the surface, as indicated in the diagram.

Near the corners the intensity of these vortices in such conditions as these is extremely high. Furthermore there is in this case a strong flow along the inside of the vortex away from its apex. These features are interdependent and together have the effect of stabilising the quick return of the fast adjacent streamlines on to the roof, and permitting the establishment of the extremely high suction coefficients mentioned above.

This flow pattern is remarkably similar to that found in certain conditions on swept-back wings of aircraft, etc. Comparing the two cases it is possible to expect special circumstances to arise at times—e.g., buildings curved in planform or " sheltered " in some particular manner—such that the vortices will originate not in a corner but at some considerable distance along an edge.

Behind the vortices the stream flows across the roof approximately in the same direction as the approaching wind and, with scarcely diminished speed, " slides off to ground " leaving a comparatively small region of quiet air in the lee of the model.

The lifting of the vortices off the surface at some distance from the corner appears to be associated with the limited length and width of the model. The longer these respective edges in relation to the other dimensions, the larger the distances of " attachment " are likely to be.

BUILD-UP OF CONICAL VORTICES

The build-up of conical vortices is best explained by starting from the 90° wind direction and is illustrated in Fig. 8 (see also Fig. 1). Figs. 8*a* (elevation) and 8*c* (plan) show the cylindrical eddy generated in 90° wind by the short edge of the roof. When the wind veers slightly (85°) it becomes distorted and surface flow occurs alongside it on the high eaves edge (Fig. 8*c*). It continues distorting with change of wind direction and gradually turns from the cylindrical eddy into a conical vortex (e.g., 50° in Fig. 8*c*—see also Fig. 7). This then decreases in diameter until it " slips off the edge " at about 20° wind.

Concurrently between 85° and 80° a narrow conical vortex becomes established along the high eaves edge and expands gradually as shown, again in plan view, in Fig. 8*b*. In the later stages, approaching 0° wind, it becomes a cylindrical eddy generated this time at the long edge.

The two developments proceed together, but expected to clarify the general approach to questions of wind loading where previous considerations have been inadequate. More comprehensive data regarding the measurements and the analysis are to be recorded elsewhere for reference.

The problem of relieving the high loadings would appear to be a matter requiring more attention than has been given to it in the past, and for this purpose model tests are probably unavoidable. Generally it appears to be desirable to prevent the development of well-defined conical vortices but it is not practicable to enter upon a discussion of this aspect of the matter at present.

ACKNOWLEDGMENTS

The paper is presented by permission of the Director, NPL. The author desires to acknowledge the expert assistance of Mr. C. F. Cowdrey B.Sc., in obtaining the appropriate measurements.

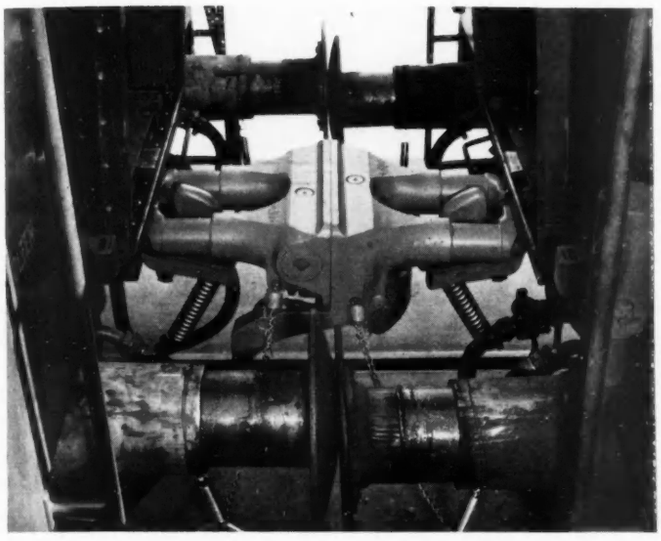
REFERENCES

[1] Ning Chien, *Wind Tunnel Studies—Elementary Building Forms*, Iowa Institute of Hydraulic Research 1951.

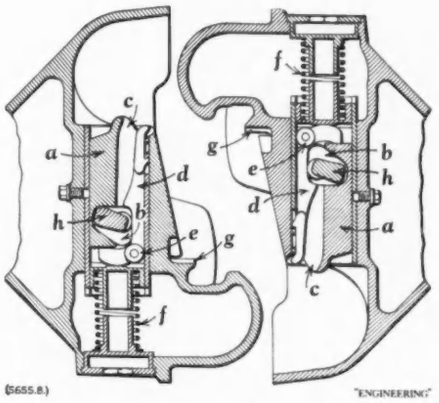
[2] Haddon J. D., " Suction on Single Slope Roofs," ENGINEERING, vol. 184, page 732, 6 Dec., 1957.

AUTOMATIC COUPLERS

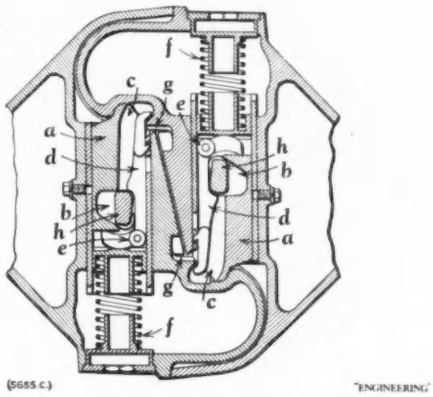
Swiss Units for Irish Railways



The +GF+ automatic coupler for railway carriages has a double locking action.



Coupler heads disengaged.



Coupler heads in engagement.

Following successful trials, the Irish Railways have placed another and larger order with George Fischer Limited, Schaffhausen, Switzerland, for the automatic +GF+ couplers which have been developed by the Swiss company for standard gauge railways. The +GF+ coupler, shown in the accompanying illustrations is of original design and incorporates a number of unusual features. It effects automatic coupling with a minimum of movement. Compensation for variation in level between trucks or carriages is provided by means of links at the ends of the coupling units. The coupler is of the rigid central buffer type.

The principle of operation may be seen by reference to the accompanying diagrams. Each coupler head has a horizontal locking bolt, *a*, with a triangular-shaped portion, *b*, at one end which acts as a guide, and, at the other end, a formed section, *c*, which is chamfered at the front. Integral with the locking bolt assembly is an adjusting pawl, *d*, turning about a pivot, *e*, and maintained in position by spring loading from a spring, *f*.

As the two coupler heads meet, a protuberance, *g*, pushes the pawl on the mating head out of its locating notch, with the result that the locking bolt is moved backwards and locates in engagement with the mating part of the opposing coupling unit. At the same time, the eccentric cam, *h*, is turned through approximately 90°, thus wedging the locking bolt vertically and thereby locking the two coupling units rigidly together. It provides, in effect, a double lock, and is so designed that even if either one or both of the couplers are already locked, inter-coupling action can still take place without risk of damage.

Uncoupling is effected by giving a jerking pull to the hand lever of each coupler. This operation turns the eccentric locking cam back into the unlocked position, releasing the locking unit which can now move out of engagement with the opposing coupler. The adjusting pawl returns to its locating notch, and the couplers are now ready for re-coupling whenever necessary. Uncoupling can be effected either manually, as mentioned above, or if a heavy pull is applied.

Special arrangements are provided for shunting operations, using a shunting pin which is inserted into the hand lever assembly and prevents the locking action from taking place. A special support is provided under the coupler head for a 2 in vacuum, or a 1 in twin valve for two compressed air mains. Couplers for remote control on railcar units can be mounted on the coupler heads. The design covers fully all relevant specifications for automatic coupling.

SUPERSONIC TESTS ON AVON INTAKE

Fairey Delta Flying Test Bed

To provide fundamental design information on the behaviour of an axial compressor engine—the Rolls-Royce Avon—over the widest possible range of flight conditions, the Fairey Delta 2 high-speed research aircraft has been carrying out supersonic low-level flight trials in Norway this summer.

Principally the trials were designed to record the pressure distribution in the engine intake at various altitudes under subsonic and supersonic flight conditions up to the maximum speed of the aircraft, while taking simultaneous measurements of the stresses in the first-stage compressor blades. The pressure distribution was measured by a traversing pitot rake which could be adjusted during flight.

Hitherto, engine intake design has been largely dependent on model testing. This is believed to be the first time that intake conditions have been recorded in actual supersonic flight. The results obtained are still under investigation, but sufficient analysis has been done to show that there is very good agreement between these results and the figure forecast from wind tunnel tests conducted on a model of the Fairey intake at the Rolls-Royce flight test establishment at Hucknall. The final correlation between the actual flight results and the model tests will provide invaluable information for the design of future supersonic intakes.

Important information was also obtained during the trials on the manner in which the load varies on the main engine thrust bearing over a wide range of subsonic and supersonic flight conditions. Again, this was a test which had not previously been attempted in flight and it yielded valuable data on the values of bearing loads under transient conditions which could not be obtained in any other way.

The recording equipment for obtaining the results is worthy of note. Every minute of supersonic flight is extremely valuable and the instrumentation was designed to obtain the maximum of information in a short period. The intakes had a bar supporting small pitot tubes for measuring the air flow. This could be traversed across the intake by the pilot through remote control to cover the whole intake pattern in a few seconds. The Rolls-Royce strain gauge equipment was arranged in such a way that the stresses were recorded on a multi-channel tape recorder, wired into the pilot's radio circuit to enable him to record on the tape the actual engine and flight conditions at a precise moment.

From the first moment, the Royal Norwegian Air Force co-operated to the limit. They offered a flying area 100 miles long by 50 miles wide in which the Fairey Delta 2 could carry out unrestricted flying down to 6,000 ft, and every facility at the first-class NATO airfield of Sola, near Stavanger. These facilities included hangars, offices, photographic equipment, maintenance bases and radio and radar fixer coverage. The exercise, known on this occasion as "Operation Delta," must be considered a great success not only in the field of aeronautical research but also in the cementing of international relations.

Continuing **Design**

LINEAR MOTION ACTUATORS

Electrically controlled air/hydraulic operated actuators or power feeds are now being made by Numation Limited, The Brackens, London Road, Ascot, Berkshire. They are designed to provide linear movement—one model has a thrust of 1,000 lb for an air input of 80 lb per sq. in and a travel of 2¼ in—with the economy of pneumatic operation and the precision of an hydraulic system. Fig. 1 shows the actuator applied to a Numation pinch valve and Fig. 2 is a cross section to show the mechanism. For the example quoted above, the time for the full traverse is 1 to 1½ sec and the movement is capable of inching (by push button control) in steps of about 0·03 in.

The unit comprises in a co-axial form an air power cylinder, 1, a hydraulic control cylinder, 2, which also serves as the air piston "rod," and a hydraulic valve mechanism, 3, for stopping, releasing or metering the flow of fluid from one side of the hydraulic system to the other.

In the position in which the hydraulic valve is shown in Fig. 2, fluid is able to pass from one side of the oil piston, 4, to the other side as the air piston is traversed, and there is no restriction on the movement of the latter beyond a smoothing-out of its action due to inherent fluid restriction in the valve porting.

When the hydraulic valve is in the upper position fluid is unable to pass from one side of the oil piston, 4, to the other, and the unit is stopped and hydraulically locked in that position. The oil piston tube, 5, with the oil piston remain stationary, the tube being screwed rigidly into the main casting, 6.

The hydraulic valve mechanism consists of the valve spool, 3, the valve tube, 7, and the pilot air piston, 8, as one sub-assembly. The hydraulic valve is operated by the piston, which moves in the short cylinder bore forming a part of the casting, 6.

Within the tube, 7, will also be seen a floating piston, 9, and a spring which together act as a recuperator for the hydraulic system; this is replenished through the oil nipple when the floating piston is seen to have reached its lower limit of travel.

Control of these two pneumatic functions—traverse and lock—is effected through two integral solenoid-operated four-way air valves, 10 and 11. Valve, 10, controls the main cylinder, while valve, 11, controls the pilot cylinder and through it the lock function.

The control valves, 10 and 11, are of normal spool design with the exception that their ports are on the bottom surface, and align with port holes in the flange of the casting, 6. Through these port holes air passes through a series of cast-in passages in the top surface of the cylinder head, 12, so that all internal piping (except for two short lengths) is avoided. One of these passages only is shown at 13. Exhaust from both control valves passes to atmosphere via, 14.

Two air inlets provide for the application where operating air pressure is to be adjustable over a range wherein the lock function might not work with consistency. Then air at the full 80 to 100 lb per sq. in can continue to be fed to the lock side by plugging off the passage. Otherwise, only one inlet need be used.

On the electrical side, in addition to the solenoid valve control, the unit mounts a number of micro-switches, 18, which are traverse-operated through the rod 15, which is attached to the air piston and passes through a seal into the upper compartment. On the end of the rod, 15, is a roller which engages with buttons, 16, mounted in slots in hinges, 17. Each switch can be operated at any point in the traverse by pre-setting the button in its slot. The inlet for electrical connections is shown at 19, while a terminal block is mounted at 20.

The unit has very wide control applications, particularly for sequence operation. One example is the connection with the pinch valve already mentioned, when the following possibilities may be cited. (A) Open, trickle and shut sequence. This is in use where a preset trickle position is required to facilitate precise weight and volume control when used on plant for bag and drum filling. The actual "trickle" position is set by button adjustment, and that switch is placed in the circuit controlling the

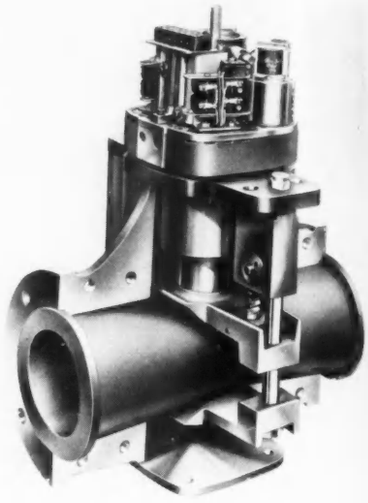
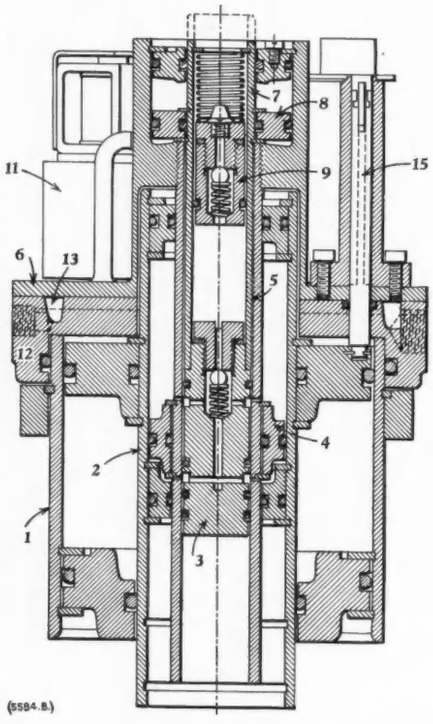
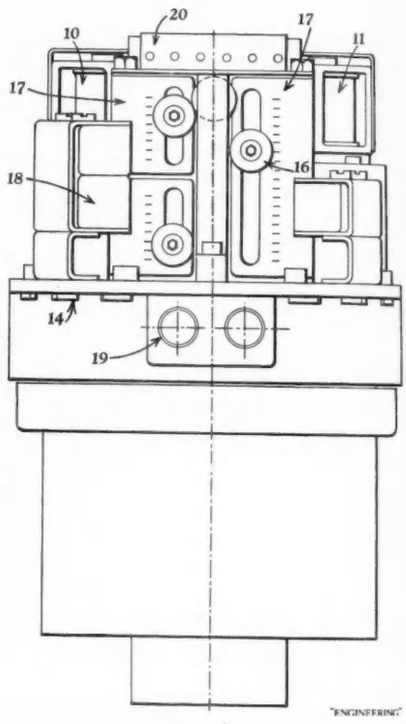


Fig. 1 One application of the Numation actuator is for a pinch valve.

Fig. 2 The operating mechanism of the valve.





"lock" solenoid valve, 11. Remaining switches can be wired into a lamp indicator circuit, and those buttons set accordingly.

(B) False open and shut sequence. This is called for where "open" flow has to be settable after installation to exactly match the input or output of processing machines in the same flow line. Here the same circuitry applies, except that the lock takes place on the opening traverse instead of the closing movement.

(C) Hunting sequence. In practice this is a combination of (A) and (B) above. It is used where the valve is required to make constant adjustment to the flow according to signals received from automatic flow and volume controllers. In function, the valve continuously hunts between two button-set positions. The "hunting" zone may be set anywhere between full open and full closed, and the "differential" governed merely by the spacing between the two operative buttons. The external circuit here can, of course, be arranged to over-ride both switches to give manually operated full open or full closed positions.

(D) Three or five position control. Used for remote manual control by selector switch. The actual positions are again set by the setting of appropriate buttons, while the selector switch merely acts to "call up" the position required. Signal lights are normally incorporated in such a circuit to give an indication of the position in which the piston is.

There are a number of other requirements essential to valve operation and these mostly concern safety and shut-down conditions. It is usually required that the valve shall close on current failure (that is, that the cylinder shall extend on de-energisation of control valve, 10). Porting inside the control valve, is so arranged that this or its opposite is achieved by merely turning the valve around through 180° on its mounting face.

It is also often specified that the valve shall always remain closed in the absence of both current and air pressure. This is possible because the pilot operating cylinder which operates the lock valve is double-acting. Having been placed in the lock position it is, therefore, self-supporting until air pressure is again applied to the unit.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
Presidential Address, by Sir Josiah Eccles. Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Tues., 21 Oct., 6.30 p.m.

CROYDON
Discussion on "Electronics in Industry." South London Branch. Greyhound Hotel, High Street, Croydon. Thurs., 23 Oct., 8 p.m.

NOTTINGHAM
"Mineral Insulated Cables for Wiring and Heating," by R. J. Cotton. Nottingham Branch. Mechanics' Institute, Trinity Square, Nottingham. Wed., 22 Oct., 7.30 p.m.

British Institute of Management

LONDON
"Computers: Top Management Appraisal," by John Diebold. Connaught Rooms, Great Queen Street, W.C.2. One-day conference, Tues., 21 Oct., commencing at 10 a.m.

British Institution of Radio Engineers

EDINBURGH
"Flight Evaluation of Airborne Electronic Equipment," by H. G. Hinkley. Scottish Section. Department of Natural Philosophy, The University, Edinburgh. Fri., 24 Oct., 7 p.m.

GLASGOW
"Flight Evaluation of Airborne Electronic Equipment," by H. G. Hinkley. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Thurs., 23 Oct., 7 p.m.

Building Centre

LONDON
Films: "Handling Bricks in Packets," exhibited by the Building Research Station. Wed., 22 Oct., 12.45 p.m.

Combustion Engineering Association

LONDON
"Operating Problems in the Use of Solid and Liquid Fuels in the Southern Area," by H. Kinsey, at 10.30 a.m.; and a Brains Trust on "Do Training and Incentive Schemes for Boiler Operators Pay Dividends," at 2.30 p.m. St. Ermin's Hotel, Caxton Street, S.W.1. Thurs., 23 Oct.

BIRMINGHAM
"Dust Collecting Plant for Industrial Boilers," by D. G. Hill. Midland Region. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2. Wed., 22 Oct., 10 a.m.

Gauge and Tool Makers' Association

LONDON
Trade Luncheon. Guest speaker: Ross Roy, whose theme will probably be "How Can British and American Business Men Best Meet the Present Economic Challenge?" Savoy Hotel, Strand, W.C.2. Wed., 22 Oct., 12.15 for 1 p.m.

Illuminating Engineering Society

BRISTOL
"Lighting in Relation to Modern Ceilings and Roofs," by Derek Phillips. Bath and Bristol Centre. The Building Centre, Bristol. Mon., 20 Oct., 7 p.m.

LIVERPOOL
Chairman's Address, by T. Jones. Liverpool Centre. Industrial Development Centre, Merseyside and North Wales Electricity Board, Liverpool. Tues., 21 Oct., 6 p.m.

Incorporated Plant Engineers

CHESTER
"The Deltic Locomotive," by P. Martin. Merseyside and North Wales Branch. The Blossoms, Chester. Thurs., 23 Oct., 7.15 p.m.

Institute of Marine Engineers

LONDON
Discussion on "Deck and Engine Auxiliaries," opened by Commander D. M. Malim, R.N. ret. Thurs., 23 Oct., 5.30 p.m.*

BARROW-IN-FURNESS
"Diesel Hydraulic Propulsion," by F. J. Mayor. Merseyside and North Western Section. Central College of Further Education, Barrow-in-Furness. Wed., 22 Oct., 2.15 p.m.

BRISTOL
"Metal Spraying and Synthetic Rubber Coating for the Prevention of Corrosion," by J. H. Payne. West of England Section. Grand Hotel, Bristol. Mon., 20 Oct., 7.30 p.m.

CARDIFF
"Conversion of the 'Ocean Layer'," by M. R. L. Hayes. South Wales Section. South Wales Institute of Engineers, Park Place, Cardiff. Wed., 22 Oct., 7 p.m.

Institute of Petroleum

LONDON
"The Petroleum Industry in A.D. 2000," by Professor E. S. Sellers. London Branch. Thurs., 23 Oct., 6 p.m.*

Institute of Road Transport Engineers

EDINBURGH
"Research on the Testing and Performance of Commercial Vehicle Brakes," by R. D. Lister. Scottish Centre. North British Hotel, Princes Street, Edinburgh. Mon., 27 Oct., 7.30 p.m.

Institution of British Agricultural Engineers

NEWCASTLE UPON TYNE
"Rotary Cultivation," by H. Fail. Northern Centre. Offices of the North Eastern Electricity Board, Carliol House, Newcastle upon Tyne. Mon., 20 Oct., 6.45 p.m.

Institution of Chemical Engineers

LONDON
"Exploratory Study of the Flow of Granules Through Apertures," by R. L. Brown and J. C. Richards. Geological Society, Burlington House, Piccadilly, W.1. Tues., 21 Oct., 5.30 p.m.

Institution of Civil Engineers

LONDON
"The Stability of Tall Buildings," by R. H. Wood. Tues., 21 Oct., 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Discussion on "The Presentation of Electrical Science in Schools," opened by G. R. Noakes. Education Discussion Circle. Mon., 20 Oct., 6 p.m.*
Chairman's Address on "Random Thoughts of a Propagation Engineer," by G. Millington. Radio and Telecommunication Section. Wed., 22 Oct., 5.30 p.m.*

BIRMINGHAM
Discussion on "Electric Traction," opened by J. A. Broughall. South Midland Education Discussion Circle. College of Technology, Gosta Green, Birmingham. Tues., 21 Oct., 6.15 p.m.*

BRIGHTON
"Operational Experience at Calder Hall," by K. L. Stretch. Southern Centre. Technical College, Brighton. Wed., 22 Oct., 6.30 p.m.*

EDINBURGH
"Supply-Voltage and Current Variations Produced by a 60-ton 3-phase Electric Arc Furnace," by Dr. B. C. Robinson and A. I. Winder. South East Scotland Sub-centre. Carlton Hotel, North Bridge, Edinburgh. Tues., 21 Oct., 7 p.m.

NOTTINGHAM
"Design of the 330 kV Transmission System for Rhodesia," by F. C. Winfield, T. W. Wilcox and G. Lyon. East Midland Centre. College of Arts and Crafts, Waverley Street, Nottingham. Tues., 21 Oct., 6.30 p.m.*

Institution of Electronics

PORTSMOUTH
Films on Electronics Topics. Southern Division. College of Technology Annexe, Anglesea Road, Portsmouth. Fri., 24 Oct., 7 p.m.

Institution of Heating and Ventilating Engineers

GLASGOW
Discussion on "Feed Water Treatment in Respect of Steam Boiler Plant, Medium and High Pressure Hot Water Systems." Scottish Branch. Scottish Building Centre, 425 Sauchiehall Street, Glasgow, C.2. Tues., 28 Oct., 7 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Recent Developments in Engineering Education in the United States of America." Education Group. Wed., 22 Oct., 6 p.m.*
Symposium on "Engine Noise and Noise Suppression," arranged by the Internal Combustion Engine Group Committee. Fri., 24 Oct., 4 p.m. (Tickets required.)

CARDIFF
"Inspection of Vehicles for Road Worthiness," by G. Grime and R. D. Lister. South Wales Branch. South Wales Institute of Engineers, Park Place, Cardiff. Tues., 21 Oct., 6 p.m.

CHELMSFORD
"Clean Rooms for the Assembly of Electrical and Mechanical Instruments," by H. C. Harris. Eastern Branch. Hoffman Hall, Chelmsford. Thurs., 23 Oct., 7.30 p.m.

GRIMSBY
"Recent Developments in Propulsion Machinery and Refrigeration Equipment for Deep Sea Trawlers," by G. C. Eddie. East Midlands Branch. Royal Hotel, Grimsby. Wed., 22 Oct., 7.30 p.m.

NEWCASTLE UPON TYNE
"Theoretical Analysis of the Stresses Induced in a Spherical Pressure Vessel Due to the Constraining Effect of a Cylindrical Skirt," by Raymond Hicks. North Eastern Branch. Stephenson Building, Claremont Road, Newcastle upon Tyne. Thurs., 23 Oct., 6.30 p.m.

Institution of Production Engineers

LONDON
"Alloy Steels; Their History, Manufacture and Applications," by R. E. Linton. Royal Empire Society, Northumberland Avenue, W.C.2. Thurs., 23 Oct., 7 p.m.

COVENTRY
"Automatically Controlled Machine Tools," by J. A. Stokes. Coventry Section. Craven Arms, High Street, Coventry. Mon., 20 Oct., 7.15 p.m.

DERBY
"Lenses: Their Manufacture and Uses," by E. Atkinson. Derby Section. St. James Restaurant, St. James Street, Derby. Mon., 20 Oct., 7 p.m.

LINCOLN
"Plastics Materials in Engineering," by A. Clark. Lincoln Section. Ruston Club, Lincoln. Thurs., 23 Oct., 7.30 p.m.

NORWICH
Film "Die Casting: How Would You Make It?" Norwich Section. Assembly House, Norwich. Wed., 22 Oct., 7.30 p.m.

Institution of Structural Engineers

LONDON
"Aluminium and Tubular Steel, as Applied to the Construction of Some Recent Aircraft Hangars," by L. E. Ward. Thurs., 23 Oct., 6 p.m.*

BIRMINGHAM
Chairman's Address, by B. C. Britton. Midland Counties Branch. James Watt Memorial Institute, Great Charles Street, Birmingham. Fri., 24 Oct., 6.30 p.m.

MIDDLESBROUGH
Chairman's Address, by D. W. Portus. Northern Counties Branch. Cleveland Scientific and Technical Institution, Middlesbrough. Tues., 21 Oct., 6.30 p.m.

Junior Institution of Engineers

LONDON
"Progress in Fluid Couplings," by J. W. Lee. Fri., 24 Oct., 7 p.m.*

Liverpool Engineering Society

LIVERPOOL
Discussion on "The Electronic Control of Machine Tools." Joint meeting with local sections of the Institutions of Mechanical and Electrical Engineers. Royal Institution, Colquitt Street, Liverpool. Mon., 20 Oct., 6.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE UPON TYNE
Presidential Address, by E. J. Hunter. Hall of the Literary and Philosophical Society, Newcastle upon Tyne. Mon., 20 Oct., 6.15 p.m.

Operational Research Society

LONDON
Annual General Meeting. Presidential Address on "Education for Operational Research," by Professor A. Kendall. Agricultural Research Council, Regent Street, S.W.1. Thurs., 23 Oct., 5 p.m.

Royal Institution

LONDON
"Treasures in the Collections of Apparatus at the Royal Institution," by Sir Lawrence Bragg. Fri., 24 Oct., 9 p.m.

Royal Statistical Society

SHEFFIELD
"Programming Problems in the Coal Industry," by Dr. M. G. Simpson. Sheffield Industrial Applications Group. Grand Hotel, Sheffield. Thurs., 30 Oct., 7 p.m.*

Royal United Service Institution

LONDON
"History of Trade Unions and Their Functions To-day," by Sir Tom O'Brien. Wed., 5 Nov., 1.30 p.m.

Scientific Film Association

LONDON
"Scientific Films in the Soviet Union," being reports by delegates to the 12th Congress of the International Scientific Film Association, which was held in Moscow in September. Messanine Cinema, Shell-Mex House, Strand, W.C.2. Wed., 29 Oct., 6.30 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"The Determination of Gases in Metals by the Micro-Vacuum Fusion Method," by E. Booth; and "The Determination of Oxygen and Hydrogen in Steel," by C. E. A. Shanahan. BISRA Laboratories, Hoyle Street, Sheffield. Tues., 21 Oct., 7 p.m.

Sheffield Society of Engineers and Metallurgists

SHEFFIELD
"Atmospheric Pollution in the Iron and Steel Industry," by J. H. Flux and F. A. Gray. Mon., 20 Oct., 7.30 p.m.

Society of Chemical Industry

LONDON
"Cavitation Damage," by Dr. D. J. Godfrey. Corrosion Group. Wed., 22 Oct., 6.30 p.m.*

Society of Engineers

LONDON
"Hydrography," by Captain G. S. Ritchie, R.N. Geological Society, Burlington House, Piccadilly, W.1. Mon., 3 Nov., 5.30 p.m.*

Society of Instrument Technology

LONDON
"A Simple Data Read-Out System," by G. P. Tonkin and J. B. Bownas. Data Processing Section. Manson House, Portland Place, W.1. Mon., 20 Oct., 6 p.m.*

CHESTER
"Problems in Instrument Manufacture," by C. H. Offord. Chester Section. Grosvenor Museum, Grosvenor Street, Chester. Wed., 29 Oct., 7 p.m.

GLASGOW
"Control Instrumentation of Nuclear Reactors," by A. B. Gillespie. Scottish Section. Scottish Building Centre, 425 Sauchiehall Street, Glasgow, C.2. Fri., 31 Oct., 7.15 p.m.

GRANGEMOUTH
"Control Instrumentation of Nuclear Reactors," by A. B. Gillespie. Grangemouth Section. Leapark Hotel, Grangemouth. Thurs., 30 Oct., 7 p.m.

NEWPORT
"The Art and Craft of Instrumentation," by J. K. Burkitt. South Wales Section. Whitehead Institute, Newport. Wed., 29 Oct., 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, W.C.1. (LANgham 5927.)
British Institute of Management, Management House, 80 Fetter Lane, London, E.C.4. (HOLborn 3456.)
British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store Street, London, W.C.1. (MUSeum 5400.)
Combustion Engineering Association, 6 Duke Street, St. James's, London, S.W.1. (WHItehall 5536.)
Gauge and Tool Makers' Association, Standbrook House, 2-5 Old Bond Street, London, W.1. (HYDe Park 3451.)
Illuminating Engineering Society, 32 Victoria Street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 2 Grosvenor Gardens, Westminster, London, S.W.1. (SLOane 0469.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, 61 New Cavendish Street, London, W.1. (LANgham 3583.)
Institute of Road Transport Engineers, 69 Victoria Street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 6 Buckingham Gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Electronics, 78 Shaw Road, Thornham, Rochdale, Lancs. (Oldham Main 6661.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield Street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1. (VICtoria 0786.)
Liverpool Engineering Society, 9 The Temple, 24 Dale Street, Liverpool 2. (Central 3717.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne 1. (Newcastle 20289.)
Operational Research Society. Apply to Mr. B. H. P. Rivett, 20 Albert Embankment, London, S.E.11. (RELiance 8151.)
Royal Institution, 21 Albemarle Street, London, W.1. (HYDe Park 0669.)
Royal Statistical Society, 21 Bentinck Street, London, W.1. (WELbeck 7638.)
Royal United Service Institution, Whitehall, London, S.W.1. (WHItehall 5854.)
Scientific Film Association, 164 Shaftesbury Avenue, London, W.C.2. (TEMple Bar 4694.)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield, 7. (Sheffield 52865.)
Sheffield Society of Engineers and Metallurgists, University of Sheffield, St. George's Square, Sheffield, 1. (Sheffield 24071.)
Society of Chemical Industry, 14 Belgrave Square, London, S.W.1. (BELgrave 3681.)
Society of Engineers, 17 Victoria Street, London, S.W.1. (ABBey 7244.)
Society of Instrument Technology, 20 Queen Anne Street, London, W.1. (LANgham 4251.)

Research and Development

MECHANICAL GOVERNOR TESTING

A test rig has been developed by Ardleigh Engineering Limited, Standard Ironworks, Colchester, on which the actions of various types of governor can be checked under conditions that simulate the normal running of internal combustion engines. Facilities are provided for testing the stability of closed loop systems, ascertaining the transient response of the governor to ramp inputs, and measuring the frequency response to sinusoidal inputs. Control devices other than governors but requiring a mechanical input can also be tested.

Basically the rig consists of a variable delivery hydraulic pump, driven by an electric motor, which drives a similar variable speed hydraulic motor. This type of drive has the advantage that it can be made to simulate an engine system both as regards speed variation and acceleration; since it has a high torque to inertia ratio, high accelerations can be obtained. The layout is shown diagrammatically in Fig. 1 and the rig itself in Figs. 2 and 3.

Referring to Fig. 1, the type V.S.G. hydraulic pump, 1, is driven by the 7·5 h.p. electric motor, M1, and normally has its output set to be greater than is required by the hydraulic motor, 2, even under conditions of maximum transients. The V.S.G. motor drives the governor through bevel gears, 3, and has on the same shaft a group of inertia discs, 10, which can be adjusted to give any required value. The oil pressure across the V.S.G. motor (and therefore the torque that it exerts) is dependent on the settings of the valves 5, 6 and 7 and on the control valve 9 which is operated by the governor output. The speed is regulated by the swash-plate setting. In general it has been found advisable to operate the rig as near the maximum oil pressure of 700 lb. per sq. in as possible.

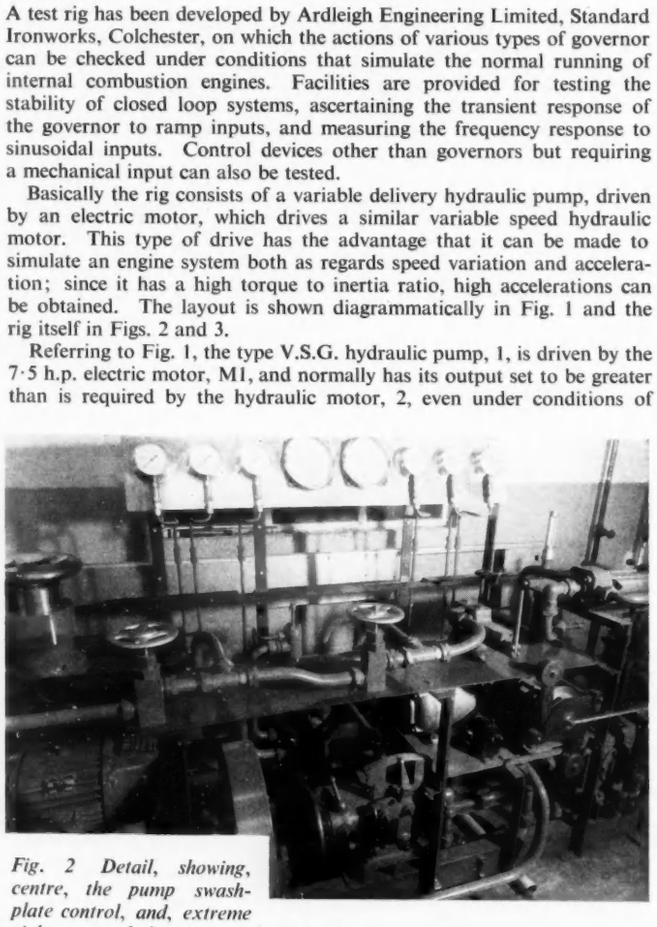


Fig. 2 Detail, showing, centre, the pump swash-plate control, and, extreme right, part of the sinusoidal mechanism.

When setting up the rig to simulate a particular engine, the first action is to adjust the number of inertia discs to obtain the correct torque to inertia ratio. Then with the valves 4, 4a, and 8 closed, the valves 5, 6, and 7 are set to represent the load torque, the dry friction torque, and the viscous torque respectively. During this setting up, allowance must be made for the inherent pressure drop across the motor. Lastly, the relative position of the governor output lever and the valve, 9, and the ratio of the linkage between them, are adjusted so that "shut down," "no load," and "full load" pressures correspond to the correct relative positions of the governor and the valve. Valves 5 and 6 have been designed to maintain a constant pressure drop across them irrespective of the flow through them.

A special valve had to be designed to serve as valve No. 7 which produces a pressure drop proportional to the rate of flow and is called the viscous flow valve; it simulates that part of the engine or load torque which has a purely viscous characteristic. To meet this condition, a laminar flow inside the valve had to be ensured even at the highest rate of flow expected in the main circuit of the rig. In examining various layouts, it was found that, in order to avoid impractical or unwieldy combinations of diameter and length, a design had to be adopted wherein the laminar flow exists in two concentric clearances between two stationary concentric cylinders and an axially displaceable sleeve which enters the space between the stationary cylinders. The axial displacement of the sleeve provides the adjustment between the pressure drop and the rate of flow. The two narrow clearances are on the inside and outside of the movable sleeve and the oil flows around the annular face of the sleeve. For the rates of flow required in the test rig (up to 15 gallons per min) clearances of the order of 0·020 in radial gap on a 5 in diameter were needed.

Valves 5, 6 and 9 have the common feature that the pressure drop they produce is adjustable, either by hand (valves 5 and 6) or by the

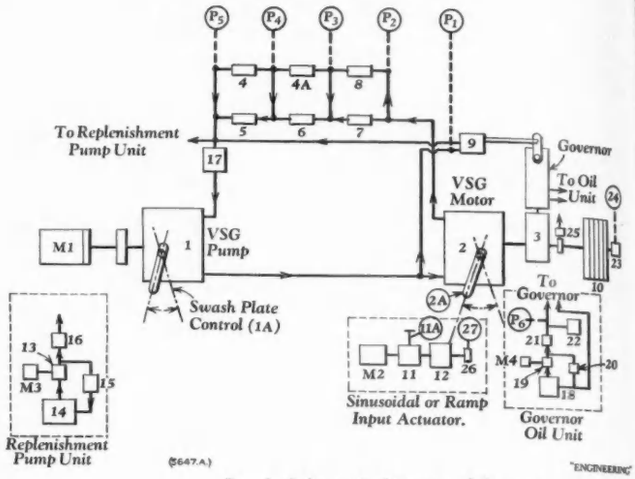
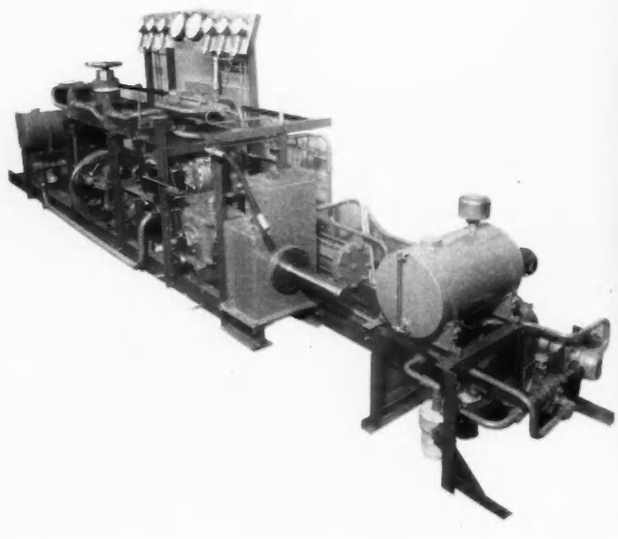


Fig. 1 Schematic diagram of the governor test-rig.

1. Vickers variable speed drive, size 1 (5 h.p.) pump unit.
1A. Swash plate control lever.
2. Vickers variable speed drive, size 1 (5 h.p.) motor unit.
2A. Swash plate control lever.
3. Bevel drive box (4 : 1), self-contained lubrication.
4. Quick acting valve, ¾ in bore, 15 gal per min.
5. Pressure drop valve independent of flow. Normal range 300 to 400 lb per sq. in. Max. flow 15 gal per min.
6. As valve (5) but range 0 to 100 lb per sq. in.
7. Viscous flow valve.
8. Simple wheel operated valve, ¾ in bore, 15 gal per min.
9. Pressure control valve, short time constant, servo operated. Range 100 to 700 lb per sq. in, with minimum pressure variation with flow. Maximum flow 15 gal per min.
10. Variable inertia made up of discs. To give acceleration rates from 50 r.p.m. per second at maximum pressure change.
11. Hydraulic infinitely variable 2 h.p. transmission.
11A. Variable speed control.
12. Sinusoidal actuator or cam-operated ramp input.
13. Replenishment pump 100 gal per hour, 100 lb per sq. in
14. Tank 5 gal.
15. Relief valve 100 gal per hour at 100 lb per sq. in.
16. Non-return valve 15 gal per min.
17. Cooler. Working pressure 1,000 lb per sq. in, capacity 19,000 B.t.u. per hour at oil temperature 160° F, water 85° F.
18. Tank 5 gal, 2 kW heater with thermostat, 60 to 200° F.
19. Oil pump 500 gal per hour at 100 lb per sq. in; 100 gal per hour at 500 lb per sq. in.
20. Relief valve 50 to 500 lb per sq. in, 500 gal per hour.
21. Oil filter, to withstand 500 lb per sq. in and 500 gal per hour.
22. Airsac hydraulic accumulator.
23. Tachogenerator.
24. Tachometer.
25. Speed pickup for oscilloscope display and filming.
26. Tachogenerator.
27. Tachometer.
P1, P2, P3, P4, P5 and P6. Pressure gauges 0 to 1,000 lb per sq. in.
M1. 7·5 b.h.p. 3-phase 400-volt 50 cycles per second induction motor with built-in centrifugal clutch.
M2. 2 h.p. 3-phase 400-volt 50 c.p.s. induction motor, 1,450 r.p.m.
M3. As for M2.
M4. As for M2.

Fig. 3 The rig as a whole with covers removed.



governor output link (valve 9); the adjusted pressure drop is independent of the rate of flow. These valves had to be specially designed and made. Clearly, the valve opening has to be varied in accordance with the rate of flow. This variation must be controlled by the pressure drop. Several principles were considered, all of which had to fulfil the conditions of (*a*) minimum variation of pressure drop within the total range of flow rates, and (*b*) the work input for the full range of adjustment simulating the fuel pump adjustment must be within the capacity of the smallest governor to be tested on the rig, and (*c*) the time constant of the moving part in the valve which ensures a constant pressure drop must be small compared with the time constant of the rig as a whole.

The principle adopted in the design of the pressure valve was a hydraulically balanced spool with a small range of motion. The pressure drop is introduced by the compression of a spring, which unbalances the piston body until a hydraulic pressure drop restores the balance.

Set up as above, the system represents a closed loop as found in most engines and the speed of the rig is under full control of the governor at all times. Since engine acceleration rates are a function of torque and inertia, the responses obtained by this arrangement are a true representation of those that would occur in practice. Consequently it is possible to determine the governor response to transients such as a sudden removal of load from an engine. In the rig this is obtained by the sudden opening of the quick-acting valve, 4, which imposes a sudden increase of pressure across the motor, 2, and therefore a sudden increase in torque. The resultant governor action is to readjust the control valve, 9, till the original pressure across the motor is restored. The various instruments on the main control panel will show the maximum overspeed that occurred. Similarly the change from no-load to full-load can be imitated by closing the valve, 4. Again the speed variation can be observed.

GOVERNOR FREQUENCY RESPONSE

A further possibility is the measurement of frequency response. For this the rig is run as an open loop with the governor output lever disconnected from the control valve and the latter locked in the full pressure position.

The sinusoidal input mechanism was designed to achieve a pure harmonic variation. The characteristic of the variable speed motor is such that the driving motor torque is proportional to the product of the oil pressure and of the angle of tilt of the motor swashplate. It was therefore necessary to transform the continuous rotary motion of an auxiliary variable speed hydraulic motor into a sinusoidally varying angle. This periodic variation of the angle of tilt of the motor swashplate must be adjustable in frequency, amplitude, and the value of the mean torque about which the fluctuation takes place. The mechanism used for this purpose first transforms the rotary motion into a linear sinusoidal motion, by a linkwork which functions kinematically as a Scotch yoke mechanism. However, the sliding pair of the Scotch yoke is replaced by another linkwork performing the duty of a straight line "motion." For this purpose a linkwork was chosen consisting of a straight link between two cranks. One point on this straight link reciprocates in an exact straight line when the cranks oscillate. Variation of the stroke was introduced by means of a screw adjustment of the crank in the Scotch yoke part of the mechanism.

The second step is the transformation of the sinusoidal linear motion into a sinusoidal angular motion of the swashplate. For this purpose an enveloping band push-pull mechanism was chosen, similar to that employed in some gear grinders to correlate the rotary and angular motions of the gear blank and the form wheel.

In this mechanism, a length of bar rolls over a segment. Precise unrolling in both directions without backlash is ensured by connecting each end of the bar with the opposite end of the segment. The segment is attached in this instance to the swashplate control lever of the hydraulic motor. A fine worm adjustment is provided to obtain a desired swashplate angle at the mean position of the oscillating motion. This ensures the desired mean torque. The frequency range from zero to 20 c.p.s. is obtained by means of the auxiliary variable speed drive provided. Ramp inputs of varying forms can be produced by using cams in place of the sinusoidal mechanism.

With this arrangement and running as an open loop, a variation of known amplitude and frequency can be imposed on a mean speed, and the relationship between input speed and governor responses can be studied. By attaching transducers and using an oscilloscope, it is also possible to determine phase changes between any two components in an open loop. Variable inputs can also be applied to a closed loop if desired.

A feature in the mechanical design is the use of disc coupling units made of two sets of thin discs at each end wherever shafts are joined. Such coupling assemblies take angular eccentric and axial misalignments by the elastic deflection of metal alone and do not introduce either backlash or excessive elasticity in the transmission of torque.

The main advantages of this rig, which was specified by Ardleigh Engineering and made by Servo Tec Limited, Finchley, London, are its ability to simulate all normal engine conditions and its versatility. In particular the valves 5 and 6, which control the pressure drop, and the main control valve, 9, offered the greatest problems and as a result of the success achieved the operating possibilities of the rig were very greatly extended.

PROTECTING EARS FROM LOW FREQUENCIES

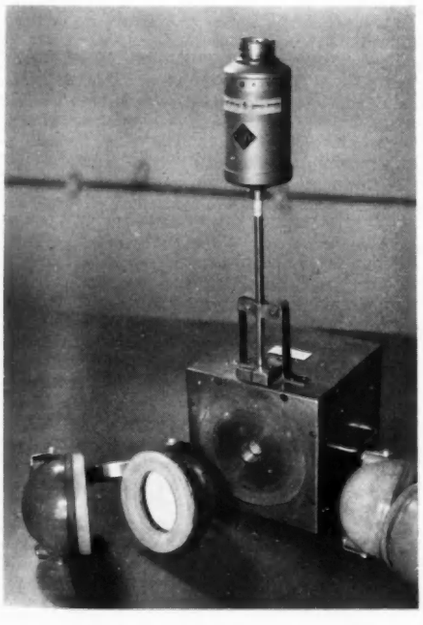


Fig. 1 The box, containing a microphone, was used to discover the way in which different frequencies were attenuated by the ear defenders, shown on the left.

That too much noise can have serious physical as well as psychological effects is now well recognised, and much attention is being directed towards improving conditions for those who must work in noisy surroundings. Suppression of noise at the source is an ideal not often attainable in the case of very noisy machinery; confinement of noise within a small area offers the next best solution, but is often expensive or inconvenient. There are still many occasions when human beings have to work (and think) in close proximity to very noisy equipment, and for them some form of ear protection is as necessary as are goggles to a welder.

An example of this kind occurs at the Admiralty Engineering Laboratories, West Drayton, Middlesex. The programme of research at this establishment includes the development of new types of anti-vibration mountings, and the design of exhaust silencers, for large marine diesel engines. This work involves long periods of full-scale testing in an enclosed test house, with diesel and gas turbine engines running at full throttle, and personnel must be present in the test house to take readings and to make adjustments.

It was found that, while commercial types of ear defender offered useful attenuation of noise —particularly at the higher frequencies—none of them provided adequate protection at the fairly low frequencies, below about 2 kc/s, produced by the Naval engines. This noise is mostly of a mechanical nature, particularly troublesome sources being superchargers and turbine compressors. Unfortunately, the latest evidence suggests low frequency noise of high intensity is the most dangerous, and may give rise to loss of hearing at much higher frequencies. In addition, long-wave sound is the most difficult to deal with, as most materials absorb the energy of high-frequency sound to a much greater extent than at the lower frequencies.

It became a matter of urgency to develop an ear defender suitable for the work concerned. Since the Laboratories were already preoccupied with the engine research work, the solution had to be simple and inexpensive, and arrived at quickly. Fortunately, progress was accelerated by news of promising developments in Canada, where similar investigations suggested that a stiff type of structure was likely to prove more effective than the soft, heavily padded devices currently popular. On this basis, the design illustrated in Fig. 1 was eventually evolved. The result is more compact than most of the padded types usually met with. The outer case consists of a simple resin-bonded glass-fibre hemisphere, which is filled with loose cotton wool whose density is carefully controlled. The seal round the edge, which must make close contact with the irregular contours of widely different face shapes, is most important. It consists of a hollow ring of flexible p.v.c. filled with water. The small amount of air entrapped allows the ring to compress under the fairly gentle pressure exerted by the headband, and thus to maintain an efficient seal even at the difficult "notch" of the jaw-bone below the ear.

The maximum attenuation achieved by the unit is about 57 db at about 2 kc/s, falling off

Continuing

Research and Development

Fig. 2 Random noise from the loudspeaker at the back of the anechoic chamber has to penetrate the ear defender to reach the microphone in the box. Analysis of the microphone output reveals the attenuation achieved.

to a minimum of about 25 db at very low frequencies. Noise loud enough to cause actual pain to the unprotected ear is reduced to about the noise of the average busy street as heard from the pavement. Because of the logarithmic nature of the ear's response to sound, a reduction by half in the apparent loudness of a noise requires a reduction by a factor of ten in the energy of the sound waves. The greatest attenuation achieved by the defenders is in fact equivalent to a reduction of sound energy by a factor of over 10^5.

This performance was achieved only after careful experiments, in the course of which the testing and evaluation of various designs of ear defenders raised some practical difficulties.

To meet the requirement of the tests, in which only the sound penetrating the ear defenders is to be measured, the equipment illustrated in Fig. 1 was devised. It consists simply of a heavy, soundproof box with a hole in one side behind which is placed a microphone with a flat frequency response. The ear defender is placed over the box, as it would be worn on the head. Any sound passing through one of the hemispheres impinges on the microphone, whose electrical output is taken, by way of a miniature preamplifier transformer on top of the vertical tube, to suitable audio-frequency analysing equipment.

The production of the offending noise at the controlled level necessary for reliable comparative test presented some difficulty. Since the criterion for the effectiveness of the ear defenders in this case is the degree to which they attenuate the diesel engine noise, live tests against the noise of an actual running engine would seem to be the most realistic approach. In practice, this is unattractive for several reasons. It would involve the prolonged running of a wide range of engine types, with a high degree of reproducibility from one test to another; even then, it would not be possible to ensure coverage of exhaust frequencies of later designs of engine. In addition, the results might be confused by uncontrolled acoustic effects, such as reverberation in the engine test house, while the time and cost involved would be considerable.

Instead of attempting to reproduce the exhaust noise of any particular engine, an instrument generating electrical noise at constant and controlled level over a wide range of frequencies was used. Known as the Type 419 White Noise Generator (made by Dawe Instruments Limited, London, W.5), the instrument produces a random electrical noise over the frequency band from 20 c/s to 5 Mc/s. The source of noise is a thyratron valve, operating in a transverse magnetic field; suitable electronic filter circuits ensure that the output level is virtually constant over the entire frequency spectrum. Three output ranges are available. The first covers the spectrum from 20 c/s to 5 Mc/s; a second has an upper limit of 500 c/s; the third, from 20 c/s to 20 kc/s, fully covers the audible band, and is the one used for the ear defender tests. Over this range, the output is constant within 2 dB. The output level, which is continuously adjustable up to a maximum of 1 volt, is directly indicated on an output meter.

The set-up used for the tests is shown in Fig. 2. The output of the generator is fed to an amplifier, and thence to a loudspeaker which is placed in an anechoic chamber. The interior of this chamber is lined with sound-absorbent material to eliminate echoes. At the rear, directly facing the microphone box on the floor, is a high quality loudspeaker. The ear defender is placed over the microphone box so that one hemisphere covers the input hole. The microphone output is fed to an amplifier and a discrete audio-frequency analyser. Having set the generator to a given level the operator adjusts the analyser tuning control through the audio band in successive steps of half an octave. The mean level of the sound as received by the microphone is thus indicated on the analyser meter. From the readings obtained, in each of a series of overlapping octave bands, a graph plotting sound level against frequency, after attenuation by the defender, can be prepared in a matter of minutes. When compared with a similar spectrum taken with the defender removed, this gives a direct indication of the actual attenuation of the defender at all frequencies.

Book Reviews

LOOKING FOR A JOB

Recruitment to Skilled Trades. By GERTRUDE WILLIAMS. *Routledge and Kegan Paul Limited, Broadway House, 68–74 Carter Lane, London, E.C.4.* (23*s*)

The Year Book of Technical Education and Careers in Industry, 1958. Edited by H. C. DENT. *Adam and Charles Black Limited, 4–6 Soho Square, London, W.1.* (30*s*)

Directory of Opportunities for School Leavers, 1958. Edited by CLIVE LABOVITCH. *Cornmarket Press Limited, 1 Lower James Street, London, W.1.* (8*s* 6*d*)

Careers Encyclopedia. Edited by G. H. CHAFFE and P. J. EDMONDS. Second Edition. *Cleaver-Hume Press Limited, 31 Wright's Lane, Kensington, London, W.8.* (15*s*)

Thirty thousand more children left school last July than in the summer of 1957. They unfortunately have ended their schooling in the middle of a recession and many are finding it difficult to get employment. How long the recession will last is uncertain, although the initiative of the Midland Bank is likely to prove important in providing a new stimulus to business. By 1962, when the school-leaver "bulge" is at its peak and over 200,000 more children are expected to leave school than in the early 1950's, it is unlikely that their employment will be the main problem, because of our ageing population. But training facilities in industry are inadequate for these large numbers. Problems of training caused by the school leaver bulge are on the agenda of the new Industrial Training Council which held its first business meeting in September.

It is not only out of consideration for the children of the post-war "bulge" that so much attention in recent months has been paid to apprenticeship and other forms of industrial training, but also more importantly because of the needs of Britain during the next few decades. Sir Willis Jackson, in his presidential address to the Education section of the British Association at the end of August referred to training inadequacies as "potentially ruinous." Unless basic industrial training is expanded and improved it is going to be difficult to provide enough skilled men as craftsmen and technicians to back the technologists and scientists now being trained in greater numbers by the Advanced Colleges of Technology and the Universities. Better training and larger numbers of trained people are essential for British industry to compete in the modern world.

An important influence in the discussions that led to the setting up of the Industrial Training Council has been Lady Williams' book on apprenticeship, "Recruitment to Skilled Trades." Like the Carr Committee, which recommended that the Council be formed, the Industrial Training Council is unlikely to be as thorough in its overhaul of training in industry as Lady Williams would like. But the formation of the Council is the first essential step towards the thorough re-assessment of training which is required.

The Council is mainly composed of representatives of the British Employers Confederation, the TUC, and of nationalised industries, but, apart from Ministries, there will also be representatives of the educational bodies on it. The Council itself can only advise, but composed as it is its advice should be followed by industrial firms. But there is as yet no sense of urgency about the new Council, any more than there was during the two years of the Carr Committee's deliberations. The 1962 "bulge" has of course been obvious since 1947, when the youngsters were born, and now it is almost on top of us.

Lady Williams provided evidence to the Carr Committee and it is hoped she will be heeded by the new Council. The research, on which her book is based, was one of the more worth-while of the Conditional Aid projects. She reviews the historical development of apprenticeship and considers in detail the apprenticeship schemes in operation in printing, building and shipbuilding as well as the many different sections of the engineering industry. She argues that apprenticeship is a traditional method of training to which inadequate thought has yet been given to fit it to modern industrial needs and that there is far too much student wastage in technical courses. "The most remarkable fact about the present system of recruiting and training young workers for skilled industry is that in all essential points it is exactly the same as the method introduced more than 800 years ago for an entirely different economy." There is something of academic scorn for industry and its methods of working in Lady Williams' attitude to apprenticeship. Apprenticeship training however mediaeval in conception has in practice provided much of industrial leadership in recent decades, although undoubtedly changes are now necessary.

The main value of Lady Williams' book, apart from its share in goading the British Employers Confederation to make preparation to act, is in its analysis of existing schemes. In engineering she found that "the burden of training future supplies of skilled workers is very unevenly spread throughout the industry.

Guidance for the Young

On the whole, in all sections the smaller establishments do not take their share, though almost all employ adult skilled men, and this means that these firms draw off the trained men from others that are fulfilling their responsibilities under the agreed scheme." In considering numbers, the problem of training needs to be re-stated as a problem of getting small firms to take on apprentices. Lady Williams refers to the Engineering Industries Association's Group Apprenticeship Scheme as the "most elaborate" effort which has been made in engineering to indent apprentices to small firms and ensure that they get a full training, but the EIAGA scheme is still small.

"Recruitment to Skilled Trades" is of general as well as of purely educational interest. It is very readable and should be read by all who are interested in industrial training or in the implications of modern industrial growth on methods of induction of young people into industry. No other equally detailed study of apprenticeship has been made in recent years.

Apprenticeship is likely to continue to open the way to careers in engineering. But with modern industry clearly demanding more and more skill, opportunities for young people are increasing both in number and in variety. The scope and range of careers available to young people have changed as compared with before the war. Britain is not only in the middle of a technological revolution, along with the rest of the world, but has since the war changed radically in two other ways. First the country has become dependent on industry more than ever before and more than almost any other country; secondly, prosperity has been experienced throughout the community and Britain has become a country of mass markets, following the pattern in the United States. Special post-war interest in technical and industrial careers results both from the rapid technical developments and the growing importance of industry as well as from the concern shown now by wider sections of the population in careers for their children. Thus advice on careers, and particularly industrial careers, is both being demanded by parents and is patently in the national interest. It is an age for books on careers. The Ministry of Labour and National Service indicated the way with its series of 86 pamphlets on careers and with its Careers Guide first published in 1950. There have been innumerable articles on careers, and at least one excellent supplement of the *Financial Times* on the subject. The Youth Employment Service has been established since the war, careers advice is accepted as a necessary function in schools, and the large industrial companies in recent years have almost fallen over one another in eagerness to offer opportunities to young people. Where there is most room for more information is on industrial careers, for not only is industry the most rapidly expanding field for future careers, (apart perhaps from entertainment) but both in grammar and public schools a long established Platonic aversion to business and industry is not yet fully conquered.

The Year Book of Technical Education and Careers in Industry, edited by H. C. Dent, previously editor of the *Times Educational Supplement* and now Professor of Education in Sheffield University, is a reference book which aims at and achieves comprehensiveness in the field. Now in its second edition, this year-book should be on the shelves of every public library, school and technical college. The publishers of *Who's Who* have achieved a second reference book of equal, if not greater value. The Year Book includes 250 pages on careers in industry, subdivided into sections by type of industry. Over 80 pages are devoted to the various fields of engineering.

The first part of the Year Book gives very full details of technical courses of all kinds in our universities, advanced colleges of technology, technical colleges, colleges of further education and special industrial colleges, such as the National Foundry College. The second part of the book includes details of advisory bodies, voluntary educational bodies and professional institutions; there is also information on training schemes in Government organisations and in industry. The Year Book is without question the main reference book on industrial training and careers.

Other books available on careers, such as the voluntary educational bodies and professional *Careers Encyclopedia*, edited by Chaffe and Edmonds, or the *Directory of Opportunities for School Leavers*, do not attempt to be in the same class as the *Year Book on Technical Education and Careers in Industry* as books of reference. The *Directory*, published by Cornmarket Press, should really be considered as one of a trilogy, the other two books being *Directory of Opportunities for Graduates* and *Directory of Opportunities for Qualified Men*, which only together give a fair coverage. The *Directory of Opportunities for School Leavers* is intended mainly for parents and young people. It has a few lightly written but scrappy articles on careers and the main portion of the directory consists of details of opportunities in a selection of larger companies, classified in an index at the end. Strangely some large companies, such as the General Electric Company, and the English Electric Company, although offering great opportunities, are omitted. The section on Professional Associations is woefully inadequate including only three organisations and, for example, no reference to any of the engineering institutions. This scrappy *Directory* gives the impression of having been produced in too much haste to be adequate in its purpose.

The *Careers Encyclopedia* is a much more thorough effort and is likely to be of value as a reference book for public libraries or schools since it includes all careers in its range. In reading the pages of such a guide one wonders at times what is the understood definition of "a career." For example "Health Visitor" and "Chemistry" are each given three pages although a whole range of careers could come under the latter heading. But this is a difficulty that would face any writer on careers. Engineering is fairly thoroughly treated although of course not in such detail as in Mr. Dent's *Year Book*. The articles on engineering are divided into four main groups, Civil, Mechanical, Electrical and Others. The last category includes Chemical, Mining, Railway, and Engineering careers in the Civil Service. Mechanical Engineering includes sub-sections on Mechanical Automobile, Agricultural, Aeronautical, Marine, Heating and Ventilating, Production and Welding. Any parent, young boy or school master reading the various articles on engineering, including production engineering, would get a clear picture of the type of work involved, of the training and examinations necessary, and of where to go for more information.

Neither the *Careers Encyclopedia* nor the *Year Book on Technical Education* refers to Industrial Consultancy as a career, or to the subject of industrial engineering which is, in effect, the field of consultancy. It is only in the last decade that consultancy has really expanded in Britain and there is still no regular path into the profession, but it is increasing in importance and for old-established industry like that in Britain, consultancy is an essential leaven if the country is going to compete abroad. Cost Accountancy, Production Engineering, Industrial and Works Management—the usual ways into consultancy—are discussed.

On the Shelf

By Frank H. Smith

The Annual Report of the Westminster Public Libraries shows a fall in book issues (4 per cent) for the first time since 1952/3. This is probably attributable to nothing other than the fact that fewer books have been borrowed. The desirability of work with children and the necessity to encourage them to read more and better books is underlined but to do this more children's librarians are needed. It is not, perhaps, realised that dealing with small fry is not just a matter of stamping the books. Much could be done if talks were given by librarians with the right touch, to children in school. I am sure that a child has only to be given a start on a book of which he has seen the TV version and he will realise that more fun can be gained from forming his own images than by having them projected on a screen. Besides, he can find out what is going to happen next simply by turning over the page instead of having to wait until next week. Westminster also have story hours for children and here, again, an accomplished reader can do much to encourage children to form their own mental images.

It is gratifying to note, too, that Westminster is forging ahead with the indexing of its historical material. Typical queries received by that department are quoted and other librarians will note with sympathy that even the largest libraries have those peculiar questions that seem to have very little root in reason.

Islington Public Libraries have sent in the annual report of the Chief Librarian and Curator. (What a difference that Curator bit makes!) He plunges straight into the business of teaching children to read and it is aback-taking to learn that more than a thousand classes a year attend the library to be shown how to use books as tools. Other interest whippers-up are stamp-collecting clubs, puppet making, play reading and "pen chum" interchange with children in Canada and Belgium.

It would be pleasant to be able to reproduce this report in full since the Librarian is obviously a man full of ideas which he is aching to put into practice. He draws my attention to his comments on the difficulty of obtaining reliable information on scientific and technical works. Aslib lists are all right as far as they go but they do not go far enough, and he suggests a cumulative digest of technical and scientific book reviews, such as those in ENGINEERING. I am afraid, though, there isn't all that paper available. I used to be quite fond of a fairly recently started technical book guide that comes out each month. They did a special edition this month on my own subject and bang went another illusion. Harking back to Islington, there are not many librarians who cope with a loan service to a man's and a woman's prison. John Gilpin's Librarian does. If, after all this, you feel you'd like to read all about it, write to 68 Holloway Road, N.7.

A list is available from Pergamon, 4/5 Fitzroy Square, London, W.1, of the publications they publish on behalf of the Advisory Group for Aeronautical Research and Development of the North Atlantic Treaty Organisation (AGARD of NATO). These are rather clumsily called Agardographs but their material is by authors who are Top People in their fields.

The chief difficulty for anybody wishing to consult the Reports and Memoranda of the Aeronautical Research Council (and these deal with many "fringe subjects" of interest to other than aeronautical engineers) is the absence of classified indexes. The most useful is a gratis issue by HMSO of a Sectional List No. 8 (with addendum) but from time to time author indexes appear and that covering the period February, 1954, to February, 1958, can now be bought from HMSO at 7*s* 6*d* It is designated R & M 2570 (revised) and includes Current Papers of the same period.

Construction

ENGINEERING REQUIREMENTS OF THE RAILWAYS

International Railway Congress in Madrid

FUNDAMENTALLY the railways are an engineering problem. Collectively the railways of the world are probably the largest owners of capital works and plant. Their ownership of bridges, buildings and the permanent way, of motive power units and rolling stock, of electrical generating and distribution equipment, of signal and telephone equipment is more extensive than any other form of authority. The opportunities of the railways to gain experience in the construction and maintenance of works and plant is therefore unrivalled; they are also one of the largest, if not the largest, purchasers of materials and products. Hence the significance of the proceedings of the International Railway Congress Association (IRCA) to engineers and industry outside the railways as well as within.

The 17th Congress has just been held in Madrid. Representatives of more than 100 railway systems of 50 countries attended, including delegates from most European countries, both North and South America, Africa, the Indian sub-continent and Australia. Discussions covered a number of specific questions: the repair and maintenance of bridges, particularly as they age; the use of long welded rails; the design and improvement of railcars and multiple-unit diesel trains; freight handling, especially in small lots; difficulties of changeover from steam to electrical or diesel traction; advantages of high-speed electronic computers; the financial aspects of replacing railway assets; and, in respect of light railways (those with low traffic densities), the reduction of operating costs and the wear and tear of rails. To all these questions the engineer makes the major, if not sole, contribution. As observed above, railways are fundamentally an engineering problem.

In these days of vast international meetings of engineers and scientists the procedure adopted at the Railway Congress which meets every four years in a different country, is of considerable interest: others have much to learn from the more mature railwaymen. Not for them several hundred (or even thousands) of papers of which a negligible few can be properly presented and discussed. When it comes to the Congress there are five working sections which run concurrently and it is the work of each section (meeting regularly during the eight days which the gathering lasts) to hammer into final form detailed surveys of current practice on two selected questions. Thus 10 questions are thoroughly ventilated.

Much work is done in advance of the meeting. Two reporters are appointed to study each question and, by the use of detailed questionnaires, they gather the views of the participating authorities, which are divided into two groups whose practices are known to be akin. The two reports thus obtained are most detailed studies of current practice. They are combined by a *rapporteur* and the resulting summary is presented at the working session for discussion, amendment and approval. The final recommendations thus form something approaching a code of practice based on all that is best in railway practice.

Also prior to the Congress, the two reports on each question are published in full, complete with detailed replies in tabulated form, in the monthly issues of the *Bulletin* of IRCA appearing from February to August. Then in the September issue, just before the Congress, the 10 papers by the *rapporteurs* are published, including the summaries to be discussed at the working sessions. Résumés of the reports have, on this occasion, also appeared in the *Railway Gazette* over the period since last April, and in their issue of 19 September there will be found a very full description of the railway systems and activities in Spain.

In such a report as this it would not be fitting to fail to acknowledge the excellent arrangements made by the Spanish hosts for the delegates and their ladies. There were ample facilities provided for the delegates to learn of the life and culture of the country; museums and galleries were made free to the visitors; a great quantity of papers and books—all of a fine quality—were presented to each delegate; and, finally, hospitality abounded, culminating in a "festival gala" at the theatre and the Congress dinner. After the Congress the delegates divided into four groups to tour the Spanish provinces.

As has been mentioned, the business of the Congress was dealt with in terms of 10 questions. In the following pages brief reports are given of the matters considered in the first four questions on the agenda, all of which are of an essentially general engineering interest. The remaining questions will be considered in a subsequent issue.

Long Life in Bridges

The first question on the agenda of the Congress is of the widest possible interest to civil and structural engineers: the problems associated with the ageing of bridges, with fatigue, corrosion or other weathering, and the associated problems of maintenance, repair and strengthening.

From the returns made to the reporter's questionnaires a very illuminating fact emerges concerning a difference between steel bridges and those built of masonry or concrete. In the case of the former the structures were originally sound and though maintenance charges have generally been heavy (to offset corrosion) the bridges have only required strengthening because of increasing loads. In contrast to this, maintenance of masonry or concrete bridges has been less costly than for those of steel, but the lack of maintenance is not thought to have been the cause of much damage. However, the list of damage due to bad initial design or workmanship on concrete bridges is very long, the most frequent causes being:—

(i) The formation of cracks; principally due to inadequate foundations or earthworks and subsidence, the absence of expansion joints, defective transverse joints in bridges built with encased girders, different degrees of rigidity in different parts of the structure.

(ii) The breaking and spalling of surfaces; this has been due to the use of bricks or stones of insufficient "strength" to stand up to the weather.

(iii) The crumbling of mortar and masonry; generally attributed to a lack of water tightness;

(iv) The disintegration of concrete accompanied by exposure of reinforcement; this is attributed to too much water in the mix, inadequate cover over the reinforcement which may also be badly arranged, action of corrosive fumes from locomotives, defective granular consistency of the concrete, and poor quality of the aggregates.

The railways also gave their estimates of the life of bridges built of different materials and the *rapporteur* summarised the returns as follows:—

(i) For metal bridges, between 50 and 100 years.

(ii) According to the American Railroads, concrete bridges have an expectation of 40 years; most other authorities put the figure between 75 and 100 years. In particular cases the limit is put at 120 years for beam bridges and 200 years for arch birdges according to the Czechoslovakian Railways; Belgian Congo put the life-span as limitless.

(iii) For masonry bridges, all authorities gave estimates of 100 years or more.

The accountants settle the issue by the simple expedient of writing all bridges off at a rate of 2 per cent per annum, i.e. give them a financial life of 50 years.

No railway authority claimed to be able to design a bridge for a given life-span; indeed, this was said to be a least considered factor, other things such as initial load capacity, ease of construction, availability of materials, being given priority; though considerable attention is now given to designing with a view to easy maintenance, by the choice of "smooth, simple designs and adequate constructional arrangements."

The principal method of preserving steel bridges was still painting after ensuring a good clean surface; red lead, iron, or zinc chromate paints were used as undercoats and white zinc, white lead, iron oxide and aluminium paints, or those with a bitumastic or tar base, as top coats. As was to be expected the period allowed between repainting varied greatly according to region and local conditions; from two years to as much as even 30 or 40 years in certain mountain areas. Stress was laid, however, on the economic advantages of partial repainting, attention being paid only to points where corrosion was particularly heavy. Methods other than painting for preservation of metal bridges—such as metalisation, cathodic protection, use of stainless steel or other alloys—have only been used in special cases. Only one authority noted the use of chrome—or copper—steel for bridge work.

Although the general strengthening of steel bridges has been found to be practicable by adding new members or by reinforcing existing members, the majority of authorities prefer to renew bridges, rather than to undertake large-scale strengthening operations; this is particularly true of the old iron bridges which will not carry the traffic loads to be expected.

Long Welded Rails

The second question considered by the Ways and Works section was that of long welded rails. The most important thing to be noted here by non-railwaymen is the general acceptance by the authorities of long welded rails (over

100 metres between joints) with the consequent change in demand from fish plates to anti-creep (anchoring) and expansion devices, ballast-packing machines and welding equipment. For the travelling public it will mean a much smoother and quieter ride.

Wherever authorities have laid down long welded rails (LWR) they have quickly become convinced of the advantages, of which there are three. First there is the suppression of shocks previously experienced every 30 ft or so at rail joints which were irritating to the traveller, caused premature damage to rail ends and rolling stock, though the magnitude of this can probably never be assessed. Second, there is an increase in rail life, estimated by some authorities to be 25 per cent and even as high as 50 per cent. And, thirdly, a saving in maintenance costs has been found which, the rapporteur comments, the least optimistic authority puts at 15 per cent.

There appears to be some disagreement on how LWR are best got into position but most favoured procedure is shop welding to the longest possible length and then welding up on site. Apart from limitations made by track connections (points, crossings, etc.) there is apparently no other restriction on the length of the rails. Heavier ballasting and longer benches are to be preferred than with conventional track and this will tend in time (apart from labour costs) to eliminate shovel packing. Anti-creep devices are necessary to hold the rails along the central portions, and best practice seems to be to fix the rails at a temperature a few degrees above the average.

Given adequate packing of the ballast and the use of a suitable sleeper (weight is important, hence the preference for concrete over timber) LWR are just as acceptable in regions where there is a large daily or annual temperature range to be accommodated. Most authorities believe it to be desirable to de-stress the rails once a year, but even this practice is not universal. There is some divergence of opinion as to the minimum curve to which such rails can be laid but, as in general tight curves (under 1,000 ft radius) will be associated with track connections, this point would not seem to be very significant; there is still ample length of straight or near-straight track to be converted.

Electric arc, thermit, oxy-acetylene and flash-butt methods of welding have been used, with a preference which is moving in favour of flash-butt welding. This method is well suited to depot work before transporting to site where thermit welding, without heat treatment, is frequently adopted. Where used, gas welds are annealed and both pre-heating and post-heating are carried out with electric-arc welding. With butt welding heat treatment is proving to be unnecessary.

No general practice for maintenance of LWR track has yet been laid down. The period allowed to elapse between track renovations will vary with the speed, weight and type of traffic operating over the section. No ballast should be removed should the prevailing temperature be more than a few degrees removed from that at which the track was initially laid or last adjusted.

As a final comment on this question it is worth-while quoting the reporter who affirmed that the practice of LWR is " likely to develop rapidly . . . and it bids fair to be the greatest [single] advance made in permanent way to date."

Operation and Maintenance

Economic Passenger Stock

(International Railway Congress in Madrid)

Railcars are being adopted by the majority of railways and are being found well suited to a wide range of passenger services; only one system, the Swedish State Railways appears to be using such stock for freight, and even there only four units are in use. Economy of operation, flexibility in working, speed and comfort—thus enabling the provision of an improved service—are the reasons for adopting railcars. These advantages, however, are bought at the expense of higher initial costs and increased maintenance charges, though fuel costs are lowered.

The design and improvement of railcars and multiple-unit diesel trains was the first of the two questions (Questions 3 and 4, respectively, on the Congress agenda) considered under the general heading of " Locomotives and Rolling Stock." Though the use of railcars is restricted to passenger services of moderate and uniform density (where possible, peak traffic is best managed by trains hauled by diesel locomotives), the range of railcar types is wide. They vary from the smallest units on stopping services for secondary lines, based on simple four-wheel vehicles and 60 h.p. engines, up to multiple-unit sets operating on long-distance services as luxury trains. These latter trains may be capable of speeds of 85 m.p.h. and the motive power is obtained from two engines of 1,100 h.p. each.

Bearing in mind the relatively high maintenance charges involved, all the railway authorities are attempting to standardise on a small number of engines which, fitted in tandem if necessary, can be made to cover a range of requirements. Four-stroke engines, water-cooled, are used almost exclusively. Engine speeds of around 1,600 r.p.m., and certainly within the limits of 1,400 and 2,000 r.p.m., are preferred. Supercharging is regularly adopted for engines of medium and high ratings and has been found to give increased powers of up to 50 per cent at the highest outputs without proportional increases in weight or fuel consumption. Below 200 h.p. super-charging is being abandoned as not being economic. The German Federal Railways have found that frequently it can be cheaper to use two or more engines taken from serial production in the motor vehicle industry rather than to employ a single large unit obtained elsewhere. Nevertheless single engines are preferred whenever they are available.

Analysis of the power/weight ratios required shows that this criterion falls within the limits of 5 to 11 b.h.p. per ton; these limits represent, respectively, the case of light traffic on easy gradients to fast traffic on severe gradients. Most of the railways recognise a need to reduce weight, especially of non-suspended components. Structurally, savings can be effected by the use of light steel construction or light alloys, and the extensive use of welding and of plastics; but the limit to lightweight construction is set by increasing costs of both design and building.

The basic design problem, however, is where to locate the engine: under the floor, including mounting on the bogie—and so procure maximum passenger accommodation—or in a special compartment. For heavier units the latter approach still seems to be best, principally because the engine can be better protected against dirt and more adequate sound proofing is practicable. On the other hand, a great deal of work is being done to obtain an underfloor mounting, suitable for engines of medium and medium-high rating, which has sufficient protection against vibration, dust, dirt and noise. Transmissions vary from mechanical—cheap and easily maintained—on light loads to hydraulic-mechanical and hydraulic or even electrical transmissions on the medium and heavy-duty stock; but in some instances where electrical transmissions have been used, these have been subsequently replaced by hydraulic systems.

As, however, all railway stock must be capable of general use, railcars have to be fitted with standard buffing and draw gear if there is any possibility that they will have to haul ordinary coaches or wagons. Past experience has shown that lighter patterns of such gear are all that are required as the loads to be drawn are light. Where no such possibility has to be entertained, automatic centre couplings (including brake air lines and control circuits) are recommended for railcars and their trailers. These offer especial advantages in those services where quick coupling and disconnection may be required.

Electric Locomotive Repairs

Question 4 on the agenda, and the second to be considered under the heading of " Locomotives and Rolling Stock," was that of the periodical maintenance and repair of electric locomotives. The emphasis was on the wear of components. Sought after were the better design of components and improved or alternative lubricants to lessen wear, more selective methods of inspection and the simpler replacement of worn parts. These objectives are fundamentally the same whether they concern rails and wheels, pantographs, commutators and brushes, or transmission gears. Allied to the consideration of wear, but fundamentally a somewhat different problem, was that of the breakdown of insulation of wiring or rotor and stator segments; there are, however, similar requirements for improved design, better inspection and easier and less frequent replacement.

In respect of the last point, the *rapporteur* noted that the insulation of traction motors was generally only to Class B, but there was a trend towards improved insulation such as glass fibre to increase the life of the motors. Similarly, arcing horns are being increasingly fitted in an attempt to prevent damage to commutators by flash-overs.

The establishment of fixed and regular inspection and maintenance schedules for each locomotive was a major concern of all the authorities and the evidence is by no means clear on whether frequent short-period inspections are, or are not, more economic than long-period inspections, but heavy overhauls are certainly very expensive because of long period (perhaps as much as 30 days) which the locomotive is out of commission. The most far-reaching development here is the effort being made to train crews to enable them to handle locomotives intelligently and to be able to report defects or symptoms after each spell of duty. To date all that is generally expected is that crews shall satisfy themselves that brakes and lights are in working order.

At all levels more certain methods of inspection are required, as also are cheaper methods of maintenance. Ultrasonic examination of axles is now well established and its use is being extended to armature shafts, supplemented by Magnaflux methods. Wear on both rails and tyres is heavier with electric stock than with the steam locomotives but the limits of tyre wear which can be safely accepted have yet to be established. (Somewhat surprisingly there is no direct evidence that speed of electric traction, by itself contributes to rail or tyre wear.)

An average annual mileage for passenger locomotives is 75,000 miles at designed top speeds of around 80 m.p.h. (which is in excess of most permitted line speeds); for freight locomotives the mileage is about 50,000 at running speeds between 30 and 35 m.p.h. Idle time is therefore still fairly considerable. Given, for example, tyre-profiling machines for reforming wheels in situ, ready means of partial dismantling and replacement by new or remade components, the availability of locomotives might well be substantially increased.

Production

CAST ROLLS *An Old Craft in a Modern Setting*

Existing records show that cast iron rolls were being made at Johnsons Ironworks, West Bromwich, Staffordshire, at least as early as 1839, and that by 1841 they were being exported as well as sold to the local ironworks. Production continued as a branch of the business now known as Johnsons Iron and Steel Company Limited until 1955, when a separate company, Johnsons Rolls Limited, Hall End Ironworks, West Bromwich, was formed to take over the roll making activities. Expansion plans prepared by the new company included modernisation of the foundry and the provision of a completely new machine shop. This work has now been completed, and the new production facilities are in operation.

Johnsons Rolls Limited produce chilled and grain rolls of all types up to a finished weight of 20 tons each, and steel base rolls up to a limit, at present, of 7 tons finished weight; this figure

Roll moulds are struck up in sections in loam, using precision spindles for accurate form reproduction.

is to be doubled in the near future. Several different alloy combinations are cast, to suit varying mill conditions. An appreciable proportion of the output is for export.

The largest single tonnage group of cast rolls is the clear chill type, which has a hard, wear-resisting body surface structure of clear chill graphite-free white iron and a tough grey iron core. Between the chilled outer zone and the core is an intermediate layer of mixed grey and white iron. The depth of the chilled layer is controlled according to the user's specification or to suit particular applications. Clear chill rolls are cast in straight carbon iron, giving two hardness grades, of 55° to 60° and 60° to 65° Shore "C" Scleroscope; in molybdenum quality, with a hardness of 60° to 65°, the molybdenum conferring increased strength and resistance to fire crazing; and in a variety of alloy irons with hardnesses ranging from 65° to 90° Shore "C." Part chill rolls, made in a hardness range from 55° to 65° Shore "C," have the chilled surface along part of the roll body only; this is usually the portion used for finishing. The remainder of the body, being sand cast, has a dense grey hard-wearing surface.

For certain types of mill, especially the continuous wide or narrow strip mill, the indefinite chill roll is particularly suitable. These rolls have a chilled surface and a tough core, with no line of demarcation between them; instead, there is a gradual fall in hardness with depth penetration. They are cast in a hardness range of from 50° to 85° Shore "C." Certain classes of hard roll are "double poured." This process, which demands great precision in its application, with split-second timing, gives a softer, tougher core to the roll, while retaining the hard outer surface.

Grain rolls, which have a controlled uniform density in depth, are widely used for such operations as roughing and finishing of structural sections. They are cast in a hardness range of 30° to 40° Shore "C" and, when alloyed, from 36° to 50°. Steel base rolls, which are cast from a high carbon, alloy-enriched steel, are heat treated for optimum strength and wear resistance in a specially constructed annealing furnace, fired on town's gas for accurate control. These rolls are made in a hardness range of 40° to 48° Shore "C."

SCIENCE AND CRAFTSMANSHIP

Roll making provides an interesting example of a scientifically-controlled operation in which there is still an important manual skill content. The relatively limited market for rolls, coupled with the large variety of types and sizes required, makes it impossible to employ quantity production techniques with their normal quality control procedures, and individual craftsmanship plays an important part in roll manufacture. Quality and precise adherence to specification are, however, such vital features of rolls that the manufacturing processes have to be subjected to rigid chemical, metallurgical and physical control throughout.

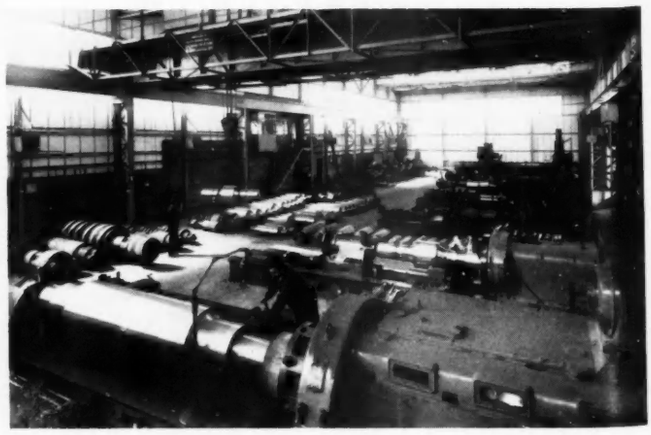
Rolls are moulded and cast in a foundry which has been completely modernised, and flow production has been introduced as far as the quantities, nature and size of the products allow. One end of the foundry is devoted to moulding box and chill storage, and adjacent to this point is an assembly area, where boxes and chills are sorted and prepared ready for use on the moulding floor, which adjoins the assembly point. Considerable numbers of boxes and chills have to be kept ready for use, to deal with the large range of roll sizes and types cast, and the foundry layout enables them to be brought together and prepared for use with the minimum of effort. The boxes and chills are handled, as are the assembled mould parts, the ladles of molten metal and the cast rolls, by two overhead electric cranes, which serve the entire foundry floor area.

Mould sections are assembled, with chills as required, to form a complete mould ready for pouring.

The bodies of profiled rolls are moulded in loam, and dry sand moulds are generally used for the roll necks and wobblers. Coke-fired mould stoves adjoin the moulding area. A small amount of green sand work is also done in the foundry, principally for maintenance purposes. Loam and sand are prepared in a building adjacent to the moulding area, and there is a one-way flow of sand and loam into the foundry and out again from stripped moulds to the preparation and recovery plant.

Moulds, complete with chills where necessary, are assembled in casting pits for vertical casting. One of the casting pits, which is intended particularly for large rolls, is at the end of the foundry, and here, out of the way of normal production work, rolls can remain to cool for periods which may be as long as a week.

Metal melting is carried out in furnaces of the reverberatory type, generally known as "air" furnaces, of which there are two at present, one of 10 tons capacity and the other of 20 tons. A third furnace, of 21 tons capacity, is being built. The existing 10 ton furnace is fired on pulverised coal and the new one will use the same fuel. Creosote pitch is used on the existing 20 ton furnace. Air furnaces are admirably suited to the preparation of relatively large quantities of molten iron when quality and



Eight centre lathes, grouped along one side of the machine shop, are available to take rolls of different sizes.

uniformity are of paramount importance, as they are for roll making. A clean iron is obtained, and the metal can be held in the liquid state until it has been tested and any necessary additions have been made to bring it to the required specification. The metal can then be tapped under precise conditions of analysis, uniformity and temperature.

ROLL FINISHING

A building adjacent to the foundry was formerly used as a machine shop, but it was not large enough to house the new equipment, so it was cleared and used as a foundry annex. Machining is now carried out in a new, steel-framed building specially designed for this work. Rolls stripped from the moulds in the foundry are lifted by crane on to a bogie on a 3 ft gauge rail track and hauled by a Ruston diesel locomotive to the machine shop, which is some 500 ft away. This means of transport is ideally suited to the heavy concentrated loads it has to carry. The rail track has been extended to a pig iron and scrap storage yard to the east of the machine shop, so that furnace charges can be carried on return journeys.

The land surrounding the new machine shop had been worked extensively in the past for coal at shallow depths, and the consulting engineers, W. S. Atkins and Partners, 52 Frederick Road, Edgbaston, Birmingham, 15, carried out site investigations before deciding on the foundation specifications. Boreholes proved varying depths of made-up ground, up to a maximum of 22 ft, the material being broken bricks and rubbish of doubtful bearing capacity. A high sulphur content was recorded all over the site. Piling was used at the heavy load carrying points, Franki piles, 17 in diameter and 37 ft average length being driven in groups of three under the crane stanchions. All the concrete used, except that for accessible floor slabs, was made with sulphate-resistant Portland cement.

High-low construction was chosen for the machine shop building, to give a good even standard of natural lighting, and the building, which is 175 ft long by 60 ft wide to the crane rails, has seven 25 ft bays, four low and three high. The height from the finished floor level to the crane rails is 20 ft. Patent glazing is used in the high bays and also at a high level in the sides of the building. Cladding is of asbestos cement sheeting with ½ in " High-lite " insulation board down to the bottom walling. This walling is of 9 in brickwork, 7 ft high all round the building except on the north end, where it is only 3 ft high; provision has been made here for future extensions of two 25 ft bays. Roller shutter doors are provided at the point of entry of the rail track at the south end, and at a further point on the east side, where they give road vehicle access to the despatch area. A single storey annex 90 ft by 10 ft on the east side houses toilets, an electric substation and the heating boiler. A second annex, on the west side, 52 ft long and 10 ft wide, is used for the toolroom, stores and messroom. This annex has an upper floor, which is occupied by the shop foreman's office.

Heating is by an oil-fired Beeston boiler with a Laidlaw Drew oil burner, which supplies low pressure hot water to 14 unit fan heaters distributed round the shop, the whole system being thermostatically controlled. Overriding controls, operated by the roller shutter doors, keep the adjacent heaters in operation when the doors are opened, irrespective of the positions of the thermostat. The boiler, together with the electrical equipment in the substation and the other services, is capable of dealing with the extra load imposed by the planned future extension of the shop. Artificial lighting is by Osram combined 250 W mercury vapour/500 W tungsten filament units, giving a value of 14 ft candles at 3 ft above floor level. Plug points at close intervals round the shop provide 110 V alternating current for individual machine lights and hand held power tools where required.

Most of the machining necessary on rolls is on cylindrical surfaces, and the majority of the machine tools installed are therefore lathes or cylindrical grinders, but a certain amount of other machining is also necessary, and horizontal borers and other machines also find a place.

A line of eight centre lathes occupies some three quarters of the length of one side of the shop; the machines range from a Harvey 27½ in lathe taking 27 ft between centres, to a Swift 11 in by 8 ft machine. Rolls for finishing flat steel and non-ferrous metals, and for certain duties in different industries, require a high standard of surface finish, combined with varying degrees of camber or barrelling, according to the work for which they are designed. Special purpose grinding machines are therefore provided, a typical example being a new Churchill roll grinder capable of grinding rolls up to 32 in diameter, and accepting 17 ft between centres.

Many types of roll drive exist, and the machining and shaping of the large variety of wobblers found in the trade has been catered for in the layout and equipment of the shop. Space has been allocated for an additional large Craven wobbler milling machine, which is due for delivery in the near future.

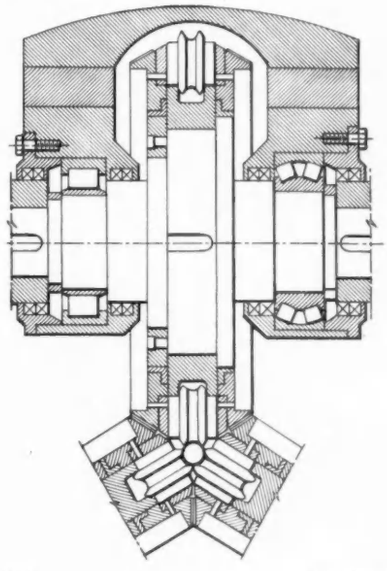
Finishing of rolls, whether large or small, plain cylindrical or with simple or complicated grooves for section rolling, is obviously an operation which cannot be mechanised, and craftsmen are again to the fore in this work. The shop layout is such, however, that work in progress flows smoothly and naturally through the sequence of operations from fettling at the south end of the shop to the packing and despatch area on the east side. Movement of rolls is by means of a Walters 15 ton floor controlled overhead electric travelling crane or by a Butterley 25 ton cab controlled crane; both these cranes serve the full area of the shop. Machining is carried out with tungsten-carbide tipped tools in all cases except where special radii are required, when high-speed steel tools are used.

DEPARTURES IN METAL ROLLING

Soviet Experimental Work

Metal rolling has developed in two main directions; it has become more highly mechanised, to produce larger quantities of higher quality materials, and it has been adapted for the production of components normally made by other methods. The first of these developments is widely known; the second is not, but the use of rolling techniques in non-traditional fields is increasing. Both these aspects of metal rolling development are considered in a recent article " Recent Advances in Rolling Mill Design due to Progress in Rolling Technology " by Professor A. I. Tselikov, Corresponding Member of the Academy of Sciences, USSR, which appeared in " Izvestia Vyshikh Uchebnykh Zaredenii ", MVP, USSR, *Mashinostroenie* No. 1, 1958.

Production by continuous rolling of products in much greater lengths than had hitherto been possible not only has the advantage of increasing labour productivity by a factor of 50 or more, but also provides a material which is already in a form suitable for further automatic operations. Thin steel strip, for example, coiled as it comes from the rolling mill, is ready for feeding to an automatic tinning or galvanising line. Butt welding can be, and is increasingly being, used to join the ends of coils to provide virtually unlimited lengths, and in a factory at Kuibishev tube is produced by rolling strip helically and continuously welding the helix. Wire drawing offers similar advantages, as a continuous length of material can be fed in without interrupting the drawing process.



(5592 A) "ENGINEERING"

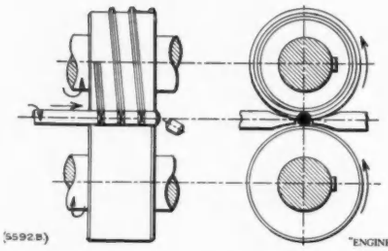
Arrangement of planetary mill for thin-walled tube.

Several possible methods of improving the hot rolling process exist. Continuous casting, coupled with continuous rolling offers many advantages, and such a combination of processes has been applied to the production of aluminium wire. In the case of steel, however, no successful installation has been reported, and a second line of approach, that of butt welding single billets or other rolling stock as they enter the first rolling stand has been adopted instead. A special welding machine is being designed to follow the metal as it travels along, and it is anticipated that a wire mill incorporating this equipment will be able to operate at 60 m/sec (nearly 200 ft/sec), that is, more than twice the speed of existing plant.

A promising method of increasing production is to step up the speed of rolling, and this can be done without major changes in plant design, for it has been established that roll pressure does not increase materially with the rate of deformation, especially in cold rolling. Increasing the speed of rolling does, however, bring problems. Rapid control of the rolled profile at the various stages of the process is difficult, because the metal being rolled is in several roll stands at the same time, and it is necessary to preserve the correct relationship between the circumferential velocities in each stand. Fully automatic control is the only answer, but much theoretical and experimental work will be needed to perfect a suitable system of control. A further problem inherent in the introduction of higher rolling speeds is that of the behaviour of the metal itself at high rates of deformation. Unfortunately, the speed of propagation of a plastic wave has not yet received sufficient study. It is also impossible at present to estimate the power required to drive high speed mills, as the effect of rate of deformation on the resistance of the metal to working is not yet known over a sufficiently large speed range.

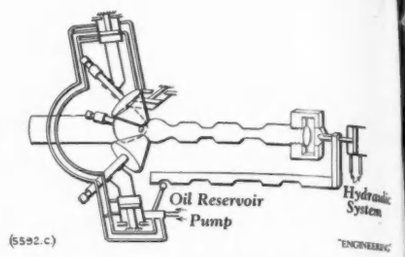
A further line of development is in the field of increased reductions per pass, as in planetary rolling mills. A new type of planetary mill for producing cold-rolled thin-walled tube was described by the author in 1956. It consists of planetary assemblies so mounted as to bear on the tube from three sides, and reduces 35 mm (1⅜ in) diameter stainless steel tube stock, with a wall thickness of 1·5 mm (1/16 in), to 30 mm (1 3/16 in) diameter, with a wall thickness of 0·3 mm (1/84 in). Another new planetary mill has a system of vertical rolls in addition to the horizontal ones used in a normal planetary mill, the

Continuing **Production**



" Screw " rolling for the production of individual components.

Guided roll pressure, applied while the hot stock is under tension, can form any required combination of diameters.



cages of the vertical and horizontal rolls being geared together. A mill of two stands, one for feeding and the other for working, will give a total elongation of 80 per cent per pass, a figure only obtainable with about 12 stands of conventional plant. Such a mill would be ideal for use with continuous casting equipment and could, for example, produce wire from large billets, up to 300 mm (12 in) square.

ROLLING INDIVIDUAL COMPONENTS

It is in the production of individual components that rolling finds, at present, its most unusual application; this process is, however, developing rapidly. A method known as " screw " rolling, developed in the USSR, is particularly suitable for producing short cylindrical articles such as rollers or balls for bearings or ball mills. Basically, the system employs a pair of rolls, one of which has a screw form on its surface; this form has the contour required to roll the finished article from the bar as it is passed between the rolls in the direction of their axes. A typical plant of this type produces balls for bearings fully automatically. The size ranges at present are from 28 mm (1⅛ in) to 80 mm (3⅛ in) diameter. Two automatic lines are being built for rolling mill balls up to 125 mm (5 in) diameter. Screw rolling is also being used successfully in the production of bicycle hubs and finned tube.

Still more unusual is a method of forming by rolling while the billet is under tension. A machine not unlike a lathe in general principles is used, but means are provided for placing the billet in tension from what could be called the " tailstock " end, and the cutting tool of the lathe is replaced by rolling equipment, which can be guided, from a template or by other means, to produce varying diameters and contours along the billet. There is, of course, no chip formation, the required shape being formed purely by rolling, not cutting. Five mills are operating on this principle in the USSR on the production of automobile components and textile spindles, and they have effected metal savings in the region of 20 to 30 per cent. The mills operate continuously, stock heating and feeding being automatic; only one operator is required. Components rolled in this way have shown an improvement in torsional strength, as compared with conventional forgings, of two or three times greater, and fatigue and impact figures are improved by 5 to 12 per cent. Automatic plant is now under development for rolling railway axles by the tension method, and it is expected to save steel to the extent of 20,000 tons a year. Development is also in hand on the production of gears by rolling and two such plants are in operation.

INDUSTRIAL STEREOSCOPIC MICROSCOPE

An inspection aid with all the optical precision of the laboratory stereoscopic binocular microscope, but with the robust construction, adaptability and simplicity necessary for use in the factory inspection bay or even during the production cycle, has been developed by W. Watson and Sons, Limited, Barnet, Hertfordshire.

The industrial stereoscopic microscope presents to the viewer an erect three-dimensional image of the object under inspection, in magnifications from × 3 to × 140. The field of view is large, and the long working distance of the objectives allows ample space in which to carry out delicate operations while viewing.

The standard instrument, mounted on a simple cast foot, is available in two forms, one with vertical eyepieces and the other with eyepieces inclined at an angle of 45°. The latter model is recommended where long hours are to be spent sitting at the microscope. The prism boxes have a lateral range of movement from 50 to 75 mm so that they may be adjusted to suit the spacing of the viewer's eyes. The boxes are gauged so that both move together when one is adjusted. The right eyepiece has provision for independent focusing to compensate for any difference in vision between the viewer's eyes.

Industrial stereoscopic microscope for three-dimensional viewing.

There is a choice of nosepieces with one, two or three pairs of objectives. All objectives are parfocalled when fitted to the nosepiece. This means that when, having focused on specimens under one objective, a change is made to either higher or lower power, only a very slight adjustment is necessary to bring the specimen again into sharp focus. Focusing is by rack and pinion, the rackwork being diagonally cut. On the standard mounting, the range of focusing motion allows the examination of specimens up to about 2⅛ in thick.

To increase the versatility of the microscope in shop conditions, a range of alternative mountings is available—for instance, to permit large surface areas to be examined rapidly, or to accommodate specimens more than 2⅛ in thick. The mountings include an axial bench clamp which can be tilted through 55° to facilitate the examination of inclined surfaces; a horizontal bar mounting on a heavy base which, in addition to allowing the microscope to be traversed, also makes provision for tilting the head; a simple long arm stand on a heavy base, allowing a range of 8 in horizontal movement of the head along the bar, 8¾ in vertical movement of the bar, rotation of the horizontal bar through 360°, and tilting of the binocular head about the bar.

An interesting point is the choice of colour for the industrial instrument: an extensive inquiry by Watson has revealed that, for industrial use, the black instruments generally acceptable to scientific laboratories are disliked—and accordingly, they no longer offer industrial microscopes in black. The most popular finish, which they are adopting as standard, is a durable light grey.

GROUP CO-ORDINATE PRODUCTION

It was announced last month that the Brush Group companies were to be integrated with the activities of the parent organisation, the Hawker Siddeley Group. Till that time, the Brush Group functioned as a self-contained unit with Hawker Siddeley. The Brush Group board has now ceased to be an executive body; the activities of diesel engine manufacture and electrical engineering have been separated. Each of these activities now has a co-ordinating executive, though the individual companies will continue to operate and sell their products under their own names.

A further practical step in reorganisation was announced last week. The range of small engines produced by Armstrong Siddeley Motors Limited at Coventry, broadly lying in the 5 to 30 b.h.p. bracket, will now be produced at the Staines factory of Petters Limited. It had previously been announced that some of the small and medium engines previously produced by J. and H. McLaren Limited at Leeds would also be produced at Staines. In future, therefore, the Hawker Siddeley Group will be concentrating its production of medium and small diesel and petrol engines at the Petters factory.

Extra space for this will be provided by the intended move of Bryce Berger Limited, fuel injection equipment manufacturers, from their present factory space adjacent to Petters to the Gloster Aircraft factory at Hucclecote. Bryce Berger have been expanding their range of products for some time and have been increasingly restricted by their present factory space.

The shift of emphasis in the Hawker Siddeley Group away from aircraft and into a wider industrial field is thus of much more than financial interest. The present changes enable the elimination of some duplication of facilities not only between the former Brush companies and Armstrong Siddeley, but also within the Brush companies themselves. They also show, what may be a pointer to the future, the intrusion of other engineering activities into the Hawker Siddeley aircraft production units. Such moves, within an integrated group, could minimise the dislocation caused by a shrinking aircraft industry.

Metals and Materials

MAGNESIA FROM SEA WATER

Britain has been made independent of foreign supplies of magnesite by development of a process to extract magnesia from sea water. Impetus to expand the plant which is run by Steetley Magnesite Company was provided mainly by war-time demand for magnesium metal.

The demand for magnesia has since been taken up by makers of refractories who are anxious to fulfil requirements of the steel industry in magnesite and chrome-magnesite bricks and ramming refractories, these materials being used to line " basic " steel furnaces.

The unique £5,000,000 plant in Hartlepool is currently processing 30,000,000 gallons of sea water a day with an annual yield of 150,000 tons of dead-burnt magnesia, sufficient to satisfy United Kingdom requirements and to allow export of refractory bricks worth £1,000,000 a year.

The extraction process involves chemical replacement of calcium in burnt dolomite by magnesium in sea water. Dolomite consists of mixed carbonates of calcium and magnesium and is straightforwardly kiln-burnt to the mixed oxides. This oxidic material known as " Dolime " is hydrated and added as an aqueous slurry to sea water. Reaction ensues between calcium hydroxide, magnesium chloride and magnesium sulphate, and yields a precipitate of magnesia, supplemented by magnesia freed from the Dolime. From thence to the final product is a simple matter of settling, filtration, drying and kiln firing. One of three settling tanks is shown in the illustration.

Extensive technical control throughout the process results in a uniform product made to a rigid chemical and physical specification, and on this basis alone the material is an attractive competitor with imported natural magnesite. Flow of process materials through the plant is smooth, and extensive instrumentation has been adopted; the flow of sea water throughout the plant, for example, is centrally controlled by one man.

The small complement of personnel numbers two hundred, which is one of the factors enabling the cost of the resultant magnesia or " Britmag " to be maintained at only 70 per cent that of imported material.

One of three settling tanks used in the Steetley sea-water magnesia plant.

Fine flakes of molybdenum disulphide produced by a quasi air-flotation method.

MOLYBDENUM DISULPHIDE

Fine Flakes

Oxidised molybdenum disulphide is of no use as a lubricant and older methods of reducing the particle size often resulted in material in just that condition. Now K. S. Paul (Molybdenum Disulphide) Limited, Great Western Trading Estate, London, N.W.10, announce that by a quasi air-flotation method they are making commercial batches of the non-oxidised pure material with an average particle size of $\frac{1}{4}$ to $\frac{1}{2}$ micron compared with $\frac{3}{4}$ to 3 microns of generally obtainable powders. Molybdenum disulphide has proved during the last few years to be a solid lubricant which is capable of withstanding pressures of over $\frac{1}{2}$ million lb per sq. in, and of operating successfully in high temperatures. This latest product should allow great advances to be made in the field of liquid dispersions in which form the lubricant is generally employed. Analysis of the " Moly-Paul Superfine " powder has indicated that the desirable flake structure is retained and that the change in pH value or extent of oxidation during processing is not detectable.

EFFECT OF PROCESSING ON THE DENSITY OF POLYETHYLENE

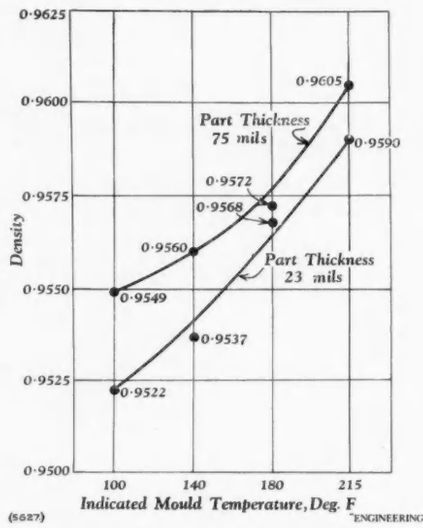
Useful information concerning the effect of processing on the density of Rigidex polyethylene has been provided by British Resin Products Limited, Piccadilly, London, W.1, in their *Technical Information Sheet No.* 8. The company are the sole selling agents for Rigidex, which is manufactured by the British Hydrocarbon Chemicals Limited under a licence from the Phillips Petroleum Company, who developed the process.

Rigidex polyethylene is made up of long chain hydrocarbon molecules that are simple in structure. The molecules pack closely together as crystallites and normally about 93 per cent of the material is in the crystalline condition and has a density of 0·96 gm per cc. When Rigidex is processed, the crystalline character of the material is affected. The change can be followed readily since very small increases in crystallinity are reflected by density increases which are easily determined. Mouldings, for example, which are exposed to the higher temperatures, stabilise after a time, at the normal degree of crystallinity of about 93 per cent. During this stabilising process shrinkage occurs and can be measured. At room temperature, density changes in the solid plastics material is extremely slow, so that even after a year only the slightest variation can be detected and shrinkage under these conditions can be considered to be negligible. With an increase in temperature, density changes proceed more rapidly; for instance, fabricated items reach uniform normal density in one hour or less at the temperature of boiling water. It is the shrinkage which is associated with substantial density increases which is of practical importance since it can be a major cause of initial and subsequent warping of moulded and other formed parts, and may cause sink marks to appear. The fit of fabricated parts can also be upset by different amounts of shrinkage in the mould, or by subsequent use at higher temperatures.

The effects of mould temperatures and cylinder or stock temperatures on the density of injection mouldings have been investigated. Typical results are shown plotted in the graph. If molten Rigidex fills a moulding cavity of uniform temperature, and if it cools and solidifies uniformly and slowly, the part will have uniform, stable density throughout. This rate of cooling depends upon melt temperature, mould temperature, and thickness and shape of the moulding. The graph indicates how a slower cooling rate

Continuing

Metals and Materials



Effect of mould temperature and part thickness on density of "Rigidex" injection moulding. Cylinder temperature 204° C (400° F).

resulting from an increase in mould temperature and thickness of moulded part, gives a higher density product. The effect of increasing cylinder or stock temperature on the density of the moulding was the more pronounced when the initial mould temperature was low, and for the parts of thicker section. These factors must be taken into account when designing a part for injection moulding and in determining the process conditions to produce maximum part density.

Similarly, extruded Rigidex products have a density determined by the method of cooling and section thickness. The effect of thickness on density is indicated in the table below.

Effect of Process and Thickness on Density of Rigidex

Thickness	Density in gm per cu. cm				
	Blown tubing	Slot extruded	Extruded sheet	Wire coating	Pipe and tube
0·0004	0·9578	—	—	—	—
0·001	0·9617	—	—	—	—
0·002	0·9624	0·947	—	—	—
0·004	0·9641	—	—	—	—
0·010	0·9653	—	—	0·9512	—
0·012	—	—	0·9537	—	—
0·017	—	—	—	0·9502	—
0·020	—	—	0·9558	—	—
0·023	—	—	—	—	0·9517
0·030	—	—	0·9582	0·9567	—
0·040	—	—	0·9621	—	0·9506
0·050	—	—	0·9625	—	—
0·075	—	—	—	—	0·9543
0·155	—	—	—	—	0·9622

Blown tubing has the highest density at a given thickness because of the slow cooling in air, and sterilisable packaging produced in this way has less shrinkage at high temperatures than slot extruded film cooled more rapidly and therefore having a lower density. Extruded sheet cast on hot polishing rolls has a density approaching that of blown tubing. Wire coatings, pipe and tubing are similarly affected by the cooling rate which is inversely related to the thickness.

Engineering at Home

SMALL BORE BOOKLET

A booklet that sets out the principles governing the design and installation of small-bore 0·5 in forced circulation system of heating is published by the Copper Development Association, 55 South Audley Street, London, W.1. *Copper Tubes for Small Bore Heating* deals with a system that has been developed by the British Coal Utilisation Research Association. The booklet explains how to calculate the heat losses —having first chosen the required room temperature—and to plan radiator positions and pipe runs; calculation of the friction losses in the pipe circuits then allows the required pump size to be found. Typical examples are worked out and friction loss diagrams for pipe circuits are given. Also included are heat transmittance data for walls and roofs.

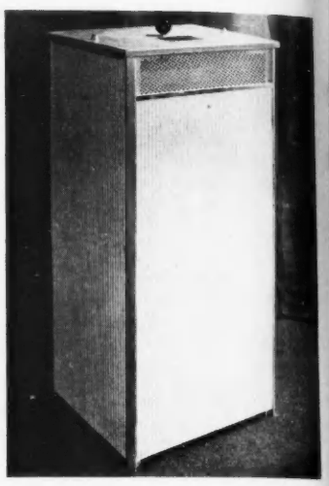
Further chapters deal with pump and control equipment and techniques of installation. The booklet concludes with a chapter on costs.

COMPACT THERMAL STORAGE

Following their 1,500 watt thermal storage heater announced last year, Dulrae Limited, Welwyn Garden City, Hertfordshire, have introduced two new "Supa-Stor" heaters. The 2,000 watt model has the same overall dimensions as the existing 1,500 watt model, but carries a greater weight of the granulated heat-storage medium. It has a storage capacity of 16 kWh. The 1,000 watt model shown in the illustration has the same height and depth as the other models but is only 14·5 in wide. It has a storage capacity of 8 kWh.

All models incorporate a control for regulating the heat output, an overheat limit thermostat, and a built-on guard shelf. The internal thermostat varies the charging period during the night in accordance with the amount of heat withdrawn during the preceding day. All installations require a suitable time switch to confine the use of electricity to within the prescribed night hours at the cheap rate; in most areas these can be obtained on a rental basis from the local Electricity Board.

The inner steel container, with heat insulated feet, is fitted with two self-contained withdrawable elements, a terminal block with an earthing screw and cable clamp. The separate non-metallic outer casing is heat insulated and is fitted with a removable lid. Wire entry is through the rear under the back panel. The powdered heat storage medium is supplied in two returnable bags, holding 112 lb each. When empty the 1,500 watt unit weights 56 lb.



The 1 kW thermal storage heater is considerably narrower than its predecessors, being only 14·5 in wide.

HOME SCAFFOLDING

Scaffolding for domestic use is produced by Mills Scaffold Company Limited, London, W.6. Three kits are available and from these towers of various sizes can be built. H frames of 1 in diameter steel tube form the basic unit and assembly is by means of a sleeve and socket fixing, no bolts or tools being required. Available accessories include base plates and castor wheels.

POWER HOUSE

A motion requiring the installation of 100 A services in all new homes built in Stratford, Ontario, Canada, has been approved by the Stratford Public Utility Commission.

ACCUMULATOR SHAVER

An electric shaver operating from a small accumulator is being manufactured by AEG (Allgemeine Elektricitäts-Gesellschaft), Germany. The accumulator provides 15 shaves of 4 minutes' duration and is charged from 110 or 220 volt a.c. mains. A charging time of about 15 hours is required from 220 volts.

STORAGE CABINET

A portable storage cabinet for such small items as nuts, bolts and washers is now being made by Smallbone and Son, Service Station, Limited, 116 Raddlebarn Road, Selly Oak, Birmingham 29, and is called the Porta-Unit. It consists of a series of heavy-gauge steel trays that work on the "Stayput" principle developed by the firm; this embodies a spring controlled movement, the trays swinging on one of the support pillars. The standard unit has nine trays, each measuring 6 in by 3 in by 1⅜ in deep, and weighs 9 lb.

ONE FOR THE POT

To simplify the process of making tea, Eltron (London) Limited, Croydon, Surrey, have produced a small immersion heater for tea pots. It is plugged into a light or power socket and placed in a tea pot containing water; when the water boils tea is introduced into the pot and the heater withdrawn. The 500 W size costs £1 9*s* 5*d*. Larger sizes are also available.

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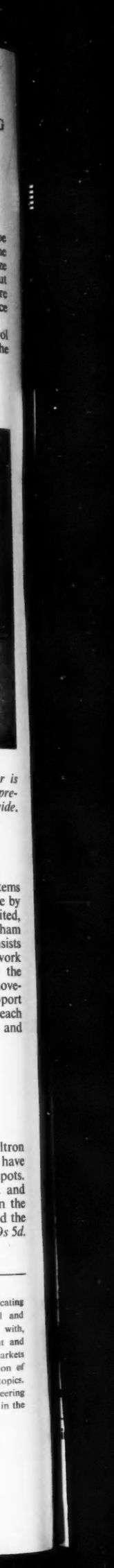
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